electronics

radio, communication, industrial applications of electron tubes . . . engineering and manufacture

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FEBRUARY
1936

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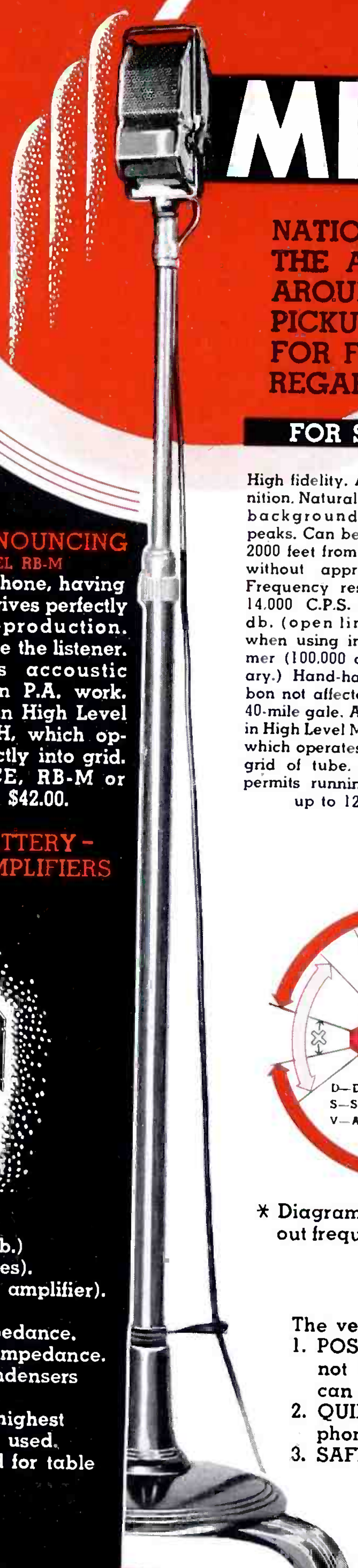
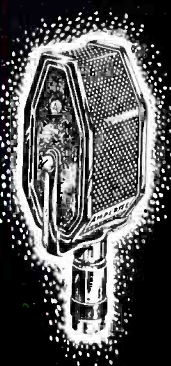
AMPERITE *Velocity* MICROPHONES



NATIONWIDE PERFORMANCE HAS ESTABLISHED THE AMPERITE VELOCITY AS THE FINEST ALL-AROUND MICROPHONE. HAS WIDEST ANGLE OF PICKUP WITHOUT FREQUENCY DISCRIMINATION. FOR FIDELITY AND QUALITY IT IS UNEXCELLED, REGARDLESS OF PRICE. SEE FREE TRIAL OFFER.



FOR ANNOUNCING
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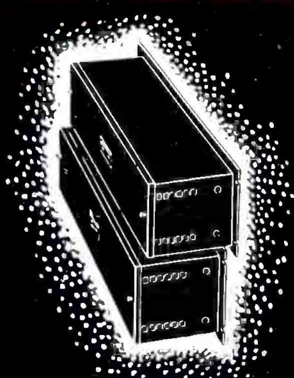

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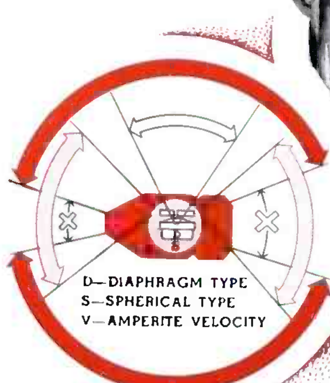
VERSATILE!

The SR-80 permits perfect reproduction for all conditions. When vertical, it has widest angle of pickup without frequency discrimination. Through a very narrow angle (X in the diagram*)the Amperite Velocity has zero pickup, which can be used to eliminate undesirable noises. For 360° pickup, simply lower the microphone and tilt until parallel to floor.

List Price (SR-80 or SR-80H) . . . $80.00. Call Letter Plate, List $5.00



* Diagram shows angle of pickup without frequency discrimination of various types microphones.

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ELECTRONICS

radio communication and industrial applications of electron tubes . . . design, engineering, manufacture

HOWARD EHRLICH, Vice-President · KEITH HENNEY, Editor · DONALD G. FINK, Associate Editor · H. W. MATEER, Manager

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February 1936

DEPARTMENTS

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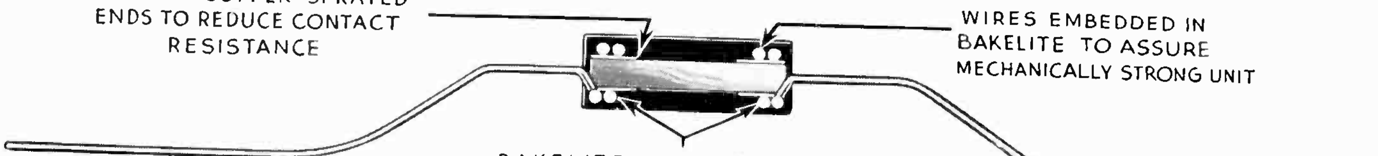
WIRES EMBEDDED IN BAKELITE TO ASSURE MECHANICALLY STRONG UNIT



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The NEW STACKPOLE MIDGET SWITCHES *and* CONTROLS

Note the design of the new straight line ½ Watt Stackpole Resistors so made that they fit into any wiring system—anywhere . . . consider too, that one size meets all requirements up to ½ Watt and you can appreciate why so many set manufacturers are standardizing their production with this new type insulated resistor.

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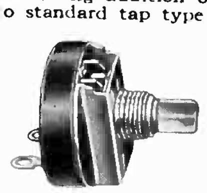
Stackpole Type M9 Switch. Rating 3-A—125-V and 10-A—10-V.

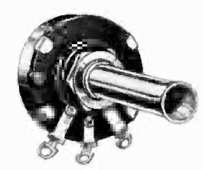
Interior view of DPST Switch with extremely low contact resistance. May be equipped with outside toggle for use in auto set control heads.

Type "P" Control with metal cover removed showing addition of friction clutch to standard tap type control.

Complete assembly of the Stackpole Midget Control with switch.



Side view of Rotary Switch mounted with bushing and shaft.



Showing addition of bell mouth sleeve construction to shaft.

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Twenty cubic yards at a bite—yet vital spots of this great shovel require the reliable protection of SYNTHANE. You may similarly guard against failure by using the same dependable insulation—SYNTHANE laminated bakelite.

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A New MALLORY PRECISION VIBRATOR

designed on the basis of experience gained in the making of nearly two million Vibrators for America's leading Auto Radio manufacturers. Available in tube types—self-rectifying types . . . and for operation from 6, 12, and 32 volts, this new Mallory development offers many advantages.

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Small Size!

The can of the new Mallory Precision Vibrator is only $1\frac{1}{2}$ inches in diameter. Its length—exclusive of prongs—is $3\frac{3}{16}$ inches. Mallory has reduced vibrator size and *increased* vibrator efficiency!

★ ★ ★

Higher Contact Pressure

assures continuity of operation under adverse conditions so frequently encountered in the field. The new tube type Mallory Precision Vibrator has 8 contacts instead of the 4 contacts usually found in vibrators of this type. The increased number of contacts adds greatly to vibrator life.

★ ★ ★

Hair-Line Precision

All contact spacings are measured with optical gauges to insure extreme accuracy. Parts are ground before assembly to insure a degree of precision not heretofore obtained in vibrator manufacture.

★ ★ ★

Grounding Cup

(as shown below) effectively grounds the can of the Mallory Precision Vibrator for the purpose of preventing interference radiation.

★ ★ ★

The enthusiastic reception of the new Mallory Precision Vibrator by the radio engineering profession is decidedly gratifying and it is predicted that great numbers of these units will be incorporated in sets produced during 1936. Write for complete details.

MALLORY VIBRATORS

ELECTRONICS

FEBRUARY 1936

KEITH HENNEY
Editor

Crosstalk

► **RETIRES** . . . At a meeting of the Board of Directors of the McGraw-Hill Publishing Company, Inc., held on December 27, 1935, James H. McGraw, the founder of the company and its head for more than fifty years, resigned as Chairman of the Board and was elected Honorary Chairman. He will remain as a member of the Board.

James H. McGraw, Jr., who has been connected with the company for the past twenty years, was elected Chairman of the Board. He has served as Treasurer and was Executive Vice President and Vice Chairman of the Board at the time of his election.

Malcolm Muir, President of the company since 1928, continues in that capacity.

► **WHAT ARE THE ULTRA-SHORT WAVES FOR?** . . . At a recent meeting of engineers, there was considerable discussion regarding the growing interest in the waves below 10 meters for use as local broadcast station frequencies. The discussion ended on the theme that these waves should not be so used, but should be reserved for other services for which they are especially fitted.

It is fair to ask what these proposed services are? Television pops into one's mind. Naturally the bands should not be cluttered with services which can be carried as well somewhere else—but television still seems to be sometime in the future. In the meantime there is a definite clamor for more broadcast channels, for high fidelity broadcasting now impossible with the present allocations.

Experience has shown that 100 watts on 7-8 meters in the center of the area to be serviced will do as well as 1,000 watts located on the edge of the area—and at much less cost and with much less distant interference production.

► **QUARTZ MARKET IMPROVES** . . . Brewing in the Capitol is a new broadcast allocation forced by the growing dissatisfaction with the multiplicity of channels occupied with chain programs, abetted by the clamor of groups now having no voice but who want their share of the ether, and aided by technological advances since the last shake-up in 1928.

Among other considerations are those granting (perhaps forcing) horizontal increase in power to 500 kw. on the clear channels (with fewer clear channels, however) and an increased number of stations. The general idea will be to give listeners better signals, especially the rural dwellers, without any increase in interference.

The clear channel stations who remain in their present status would be faced with the vast outlay required for a new super-power station; those who found themselves on shared channels would be forced to raise their level; there would be less necessity for the many chain stations since a smaller number of high-powered stations could carry the advertiser s message to the country.

► **BIG NOISE**. . . . At the December meeting of the I.R.E., in New York, mention was made of mysterious signals which rampaged over a rather wide band of frequencies and over a wide range in time and distance. Records of this noise recorded by RCA Communications were played for the audience.

In this issue of *Electronics* is a remarkable story of how the radio men at Cruft Laboratory traced down the source of this racket, finding it to be a type therapeutic machine widely used. A machine in Cambridge, Massachusetts, was heard in Washington, so strong was the radiation and so potent the skywave.

Now we learn that the RMA-SAE joint committee on ignition interference considered the problems of radiation so serious that the RMA has set aside a substantial fund to be used in an investigation of measuring equipment to be used in a survey. Mr. L. C. F. Horle, consulting engineer of New York City, has been retained to work up the design of this apparatus.

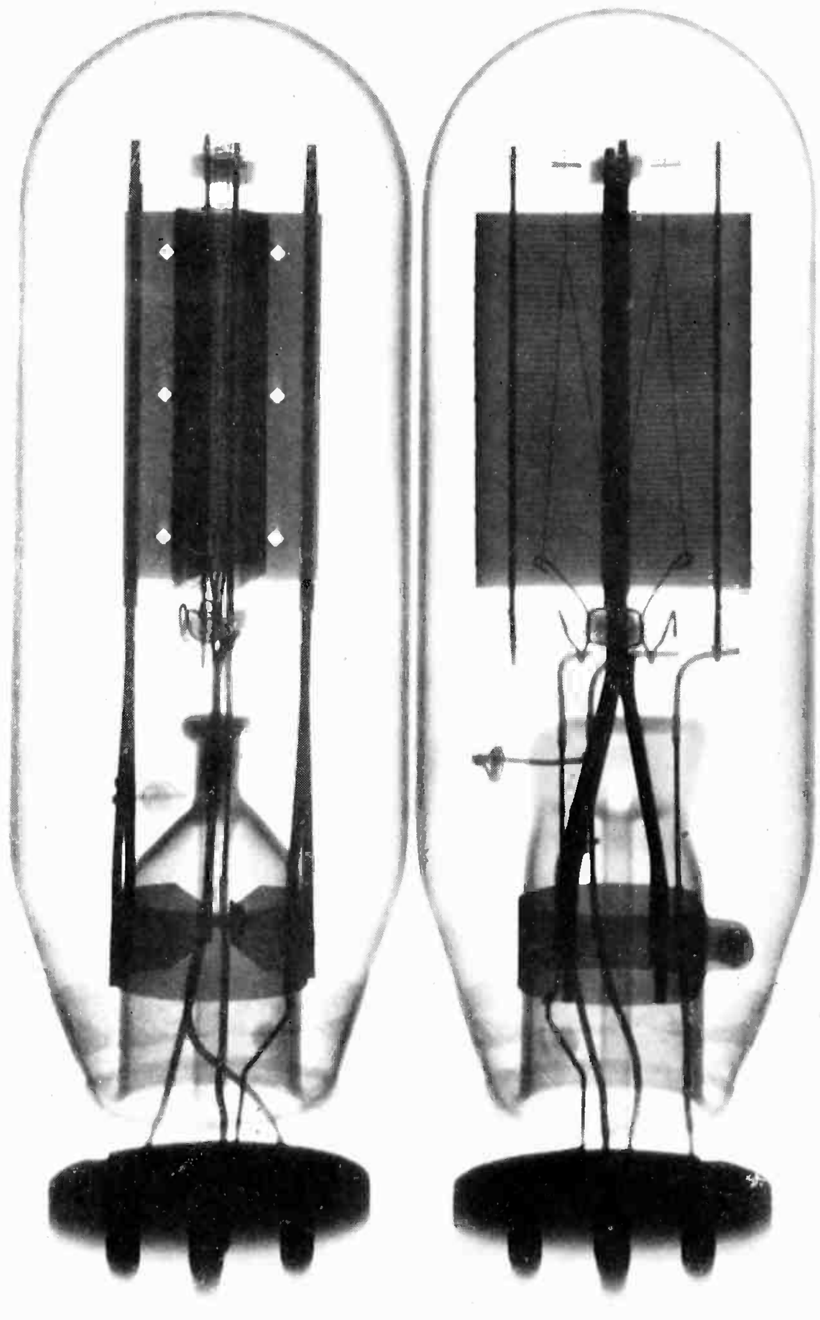
► **TRUE STORIES**. . . . Beginning in this issue of *Electronics* is a series of stories of actual experiences of industrialists and others in electronic devices. These articles will aim to tell of success, or failure; they will probably show that many tube equipments show up defects in existing methods, which are promptly improved—with the result that the tube goes back on the shelf. They will probably show that a good knowledge of tube characteristics is not all that is necessary to make tube devices work in a factory, that the most successful engineer in this new field is one who has a broad grasp of mechanical and electrical engineering with a good knowledge of optics thrown in for good measure.

We know of but a few expert electronics men, one is Rex McDill in Cleveland, another is Ralph Powers of Detroit, another is F. H. Shepard of RCA Radiotron. Each is resourceful in adventuring into new ways of doing things, none is held back by the conventions of an older art.

The editors will welcome experience stories for this series, to be published with or without company name, as the writer thereof desires. We want the facts.

► **BLIND ALLEY**. . . . The owner of a large chain of restaurants operating in England has approached an American engineer, skilled in tube applications, requesting him to work out a scheme of automatically sorting the cashier tickets into divisions which will show the amounts paid per person per meal. At present he has about 200 girls ranging from 14 to 19 years of age at this job. He states that he is not anxious to get a machine that will save money, he is willing to install the machine if it costs as much as the salaries. The owner states that *he does not feel he has any right to employ this many people in blind alley jobs!*

We would like to have the sociologists, the anti-technicians *et al.* mull over this remarkable angle on electronic apparatus.



Grid · Filament · Plate

X-ray photograph of 203A tube. Collar of aluminum and alumina insulation do not show because of their low atomic number

Industrial X-Ray Practice

A timely review of the present-day uses of x-rays in production testing, inspection, and industrial research, together with practical information on the necessary equipment and the cost of its installation

By **ROBERT C. WOODS**
Consulting physicist

IN November, 1895, Wilhelm Konrad Roentgen, then Professor of Physics in the University of Würzburg, announced the discovery of a new radiation named by him X-rays and now often called Roentgen rays. A few days later experimenters on both sides of the Atlantic were producing X-rays and feverishly exposing photographic plates like children with a new toy.

Although the first radiographs made by Roentgen himself were of instruments, keys, and metal parts, it was not for twenty years that any real industrial significance was attached to X-rays. In 1916, however, Coolidge supplanted the old unreliable gas-filled X-ray tube with the high-vacuum, hot-filament tube, making the use of X-rays a far more practical and reliable science. Since that year, industrial applications have been extended until it might truthfully be said there is scarcely an industry in which X-rays could not be of some value.

The Physics of X-Rays

X-rays are the external evidence of an internal atomic catastrophe, and indicate, by wave length, the extent of the damage. To persuade an atom to give up energy in X-ray form, we must impart to it energy from an outside source. We can do this by firing high-speed electrons into the atom with the hope that some of them will strike a vital spot. Unfortunately, by far the greater number of these projectiles pass through the atom's relatively "wide open spaces" without inflicting serious injury, but some succeed in upsetting the balance to such an extent that X-rays are emitted. By increasing or decreasing the number of electrons fired we increase or decrease the chances of obtaining X-rays, and by regulating the speed of the electrons we may control the wave length of the released rays.

The atom is like a coin gambling machine. We put energy into the atom in kinetic form and it is returned to us in X-rays. Like most gambling apparatus, however, we always put more in than we get back. This is not to say that we put more energy into the atom than comes out, but that only about 0.8% of the input is returned in the usable X-ray form.

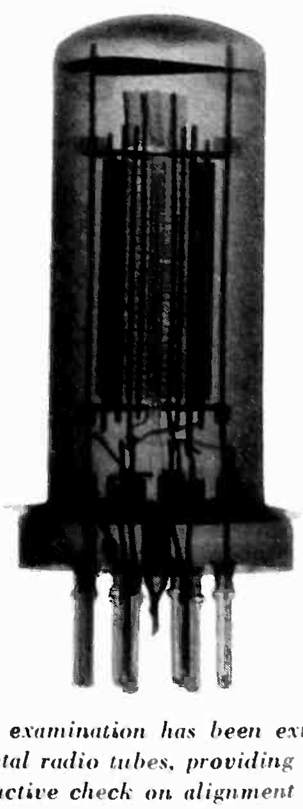
The actual quantity or amount of emitted radiation is called the intensity and is an entirely separate thing from the wave length, which depends not on the number of bombarding electrons but on their speed. In turn, the speed of the electrons depends on the force propelling them toward the atom and varies as the square root of that force. In an X-ray tube, the force is the applied voltage and usually ranges from 10,000 to 300,000 volts, with some machines built to operate at 1,000,000 volts.

X-rays are propagated in straight lines, traverse space at 186,000 miles per second without any transference of matter, are capable of being reflected, refracted and diffracted, and are unaffected by electric or magnetic fields.

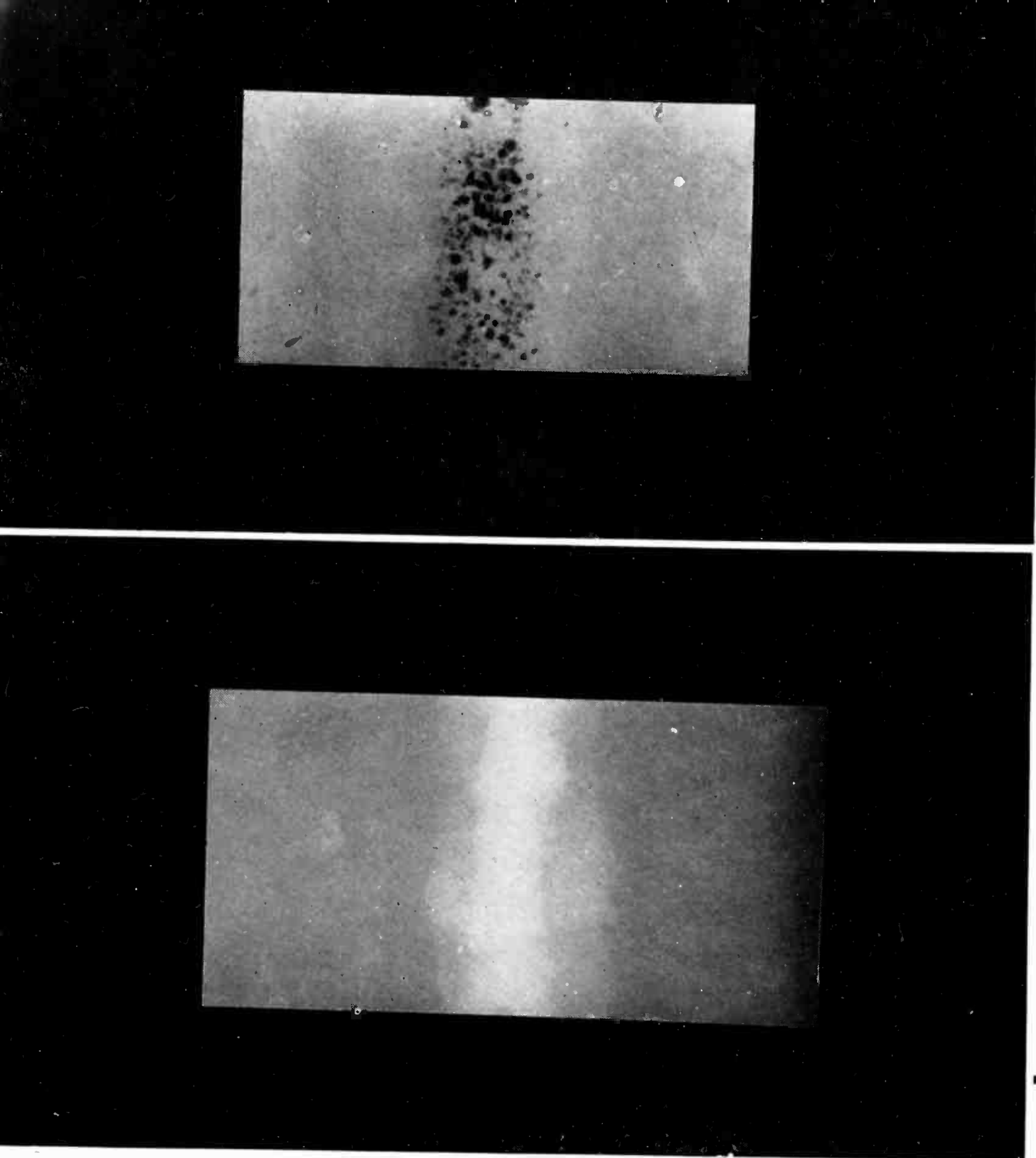
X-rays are absorbed by matter in a ratio governed by the wave length of the rays and the density of the substance upon which they fall, the short-wave rays being the most penetrating and the high density materials showing the greatest absorption power. The whole science of radiography, both medical and industrial, is based on this fact. For example, a given volume, which has a different density from the surrounding substance, will absorb X-rays in different ratio from the rest of the substance. This variation, when registered on a film, will indicate the size, shape, position, and relative density of the area.

Industrial Applications

The most widespread use of X-rays in industry at present is among manufacturers of castings (steel, brass, aluminum, etc.), forgings, and welded articles. In these fields the use of X-rays should be applied as a control for manufacturing processes rather than as a feeder for the scrap heap. X-rays in the foundry should be a regulating factor for chilling, and gating operations, and an instructor on welding technique in the pressure vessel plant. Only in rare instances is complete X-ray inspection of the entire output either practical or necessary,



X-ray examination has been extended to metal radio tubes, providing a non-destructive check on alignment of the elements after assembly, exhaust etc.



A defective and a perfect weld made by the same operator using two different methods. The X-ray is of great use in developing welding methods and technique, testing operators' skill

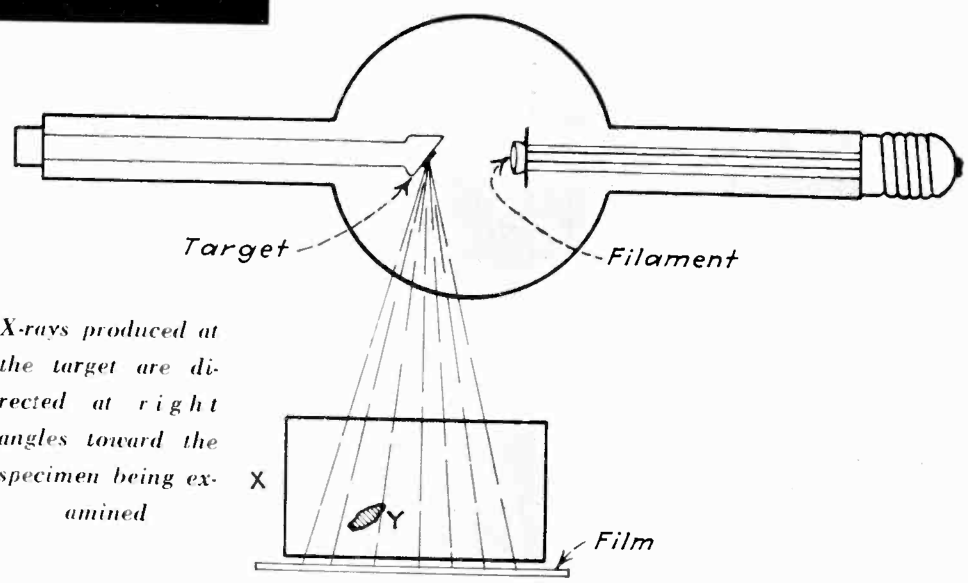
although it is sometimes specified in weld examination. For example, every inch of the 400,000 feet of welding on the Boulder Dam was X-rayed on location, and in many codes for fired and unfired pressure vessel inspection a higher safety factor is assigned to welds which have been radiographed and defects repaired.

It is also an interesting fact that many inter-company disputes over soundness of purchased articles have been settled by X-ray. Any destructive test, of course, would ruin the product.

Defects in castings, welds, forgings, and like metal parts most readily disclosed by X-ray examination are (1) cracks, (2) gas pockets, (3) sand and slag inclusions, (4) pipes, (5) porosity, (6) metal segregates and precipitates, and (7) pronounced granular fracture. Any of these or similar defects which vary the metal density at any point by 2 per cent or more may be considered detectable by X-ray methods.

Use of X-rays to determine correctness of alignment in assembled articles ranks second only in importance to casting, forging, and welding work. The same advantage of non-destructive testing applies in this field where it is valuable to view the internal relations or operation of assembled mechanisms. This is especially true with metal radio tubes, both receiving and transmitting, where circuit tests demonstrate trouble but do not indicate its exact nature or location. Several radio tube concerns maintain their own X-ray plants for inspection.

X-ray technicians, following "try everything" methods, have managed to make X-ray pictures of a tremendous number of things, many of which are useful, some artistic, and some merely bizarre. Thus X-rays have been used to show the presence of pearls in oysters, to count age-rings in trees, to determine relations of rubber and fabric in tires, to show the condition of tooth paste in tubes, to show likely ash content in coal, to detect artificial gems, to study art objects, and to show the character of goods in suspected parcels and supposedly contraband shipments. During the Great War one zealous Army inspector used X-rays to examine a load of unexposed films destined for the aerial photography section. Needless to say, none of the pictures taken with that batch of films amounted to anything.



X-rays produced at the target are directed at right angles toward the specimen being examined

A recent development rather similar to the assembly problem is the use of X-rays to detect foreign articles in food, canned goods, candy, tobacco, and like commodities. Most work in this field makes use of the fluorescent screen, the items passing on a conveyor belt through the X-ray beam which causes fluorescence on the screen and registers a shadow of the inside of the examined article.

The fluorescent screen is not, in general, of much industrial use, since it is relatively insensitive except where the density of the inspected objects and the accuracy required are low.

One large firm, tiring of lawsuits brought by persons allegedly finding metal pieces in candies, installed 100% X-ray inspection on every box of candy sold over their counters. X-rays have not only been used to disclose the presence of undesirable materials in meats, tobacco, and canned goods, but to determine the proportion of fat to lean in beef. Ham bruises, caused in shipping, have a habit of setting up a progressive inward deterioration, the extent of which is unpredictable except on opening the ham. X-rays have been used on such occasions with excellent results. Differentiation between good and bad eggs is another possibility which has been tried successfully, albeit not economically. Perhaps the future will find the X-ray a court of final appeal in the meat, canned goods and poultry industries.

There is a branch of X-ray study, as yet unpublicised, yet none the less active and valuable. That X-rays cause unusual effects on some chemical compounds has been known for years, but to date nothing of any recognized commercial importance has resulted from these researches, aside from the photochemical effect on film emulsions. Even though the various X-ray-chemical phenomena are not fully understood, there are literally hundreds of changes wrought by this method and it seems likely that industry will one day derive great profit from some startling discovery in this line. A few effects are the changing of starch to dextrin, the inversion of cane-sugar solutions, reduction of potassium iodide to iodine, the purple staining of glass, flocculation of colloids, increase of certain catalytic activity, and the explosion of hydrogen in the presence of waterdroplets.

X-Rays and Crystals

The wave length of X-rays is exceedingly tiny, being some hundred millionths of a centimeter. It so happens that the same dimension applies to the crystalline construction existing in practically all forms of matter.

In solid bodies the atoms are so closely packed that they are forced into neat rows, and the rows into sheets perfectly arranged at regular distances apart. The resulting structure is known as a crystal, each chemical compound having its own crystalline form by which it may be identified.

The sheets or plane faces of crystals affect X-rays in a manner similar to a grating diffracting a light beam.

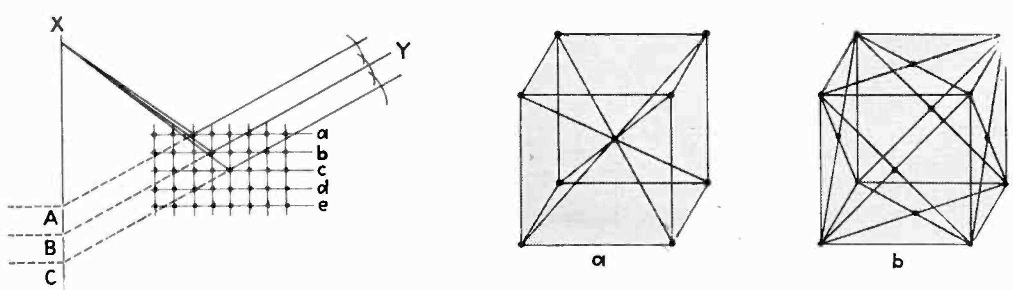
Consider what happens when a wave train from X falls obliquely on a crystal having its atoms arranged in sheets *a*, *b*, *c*, *d*, etc.

The energy is reflected from plane *a* as if originating at A, from *b* as if at B, from *c* as if at C, etc. The reflected wave front at Y is the joint effect of all waves superimposed but having definite phase relations with each other. A photograph of the result will be similar to one of a light beam diffracted at the grating ABC. If the crystal is at the proper angle, the wave from *b* will be exactly one wave length behind that from *a* and the two will reinforce each other; that is, will be in phase. Otherwise, the phase opposition cancels the effect and the result is zero. By careful consideration of the angle of reflection and wave length of radiation, the atom-arrangement of the crystal may be calculated. The relation of the scattered radiation to the reflecting plane is expressed in the equation,

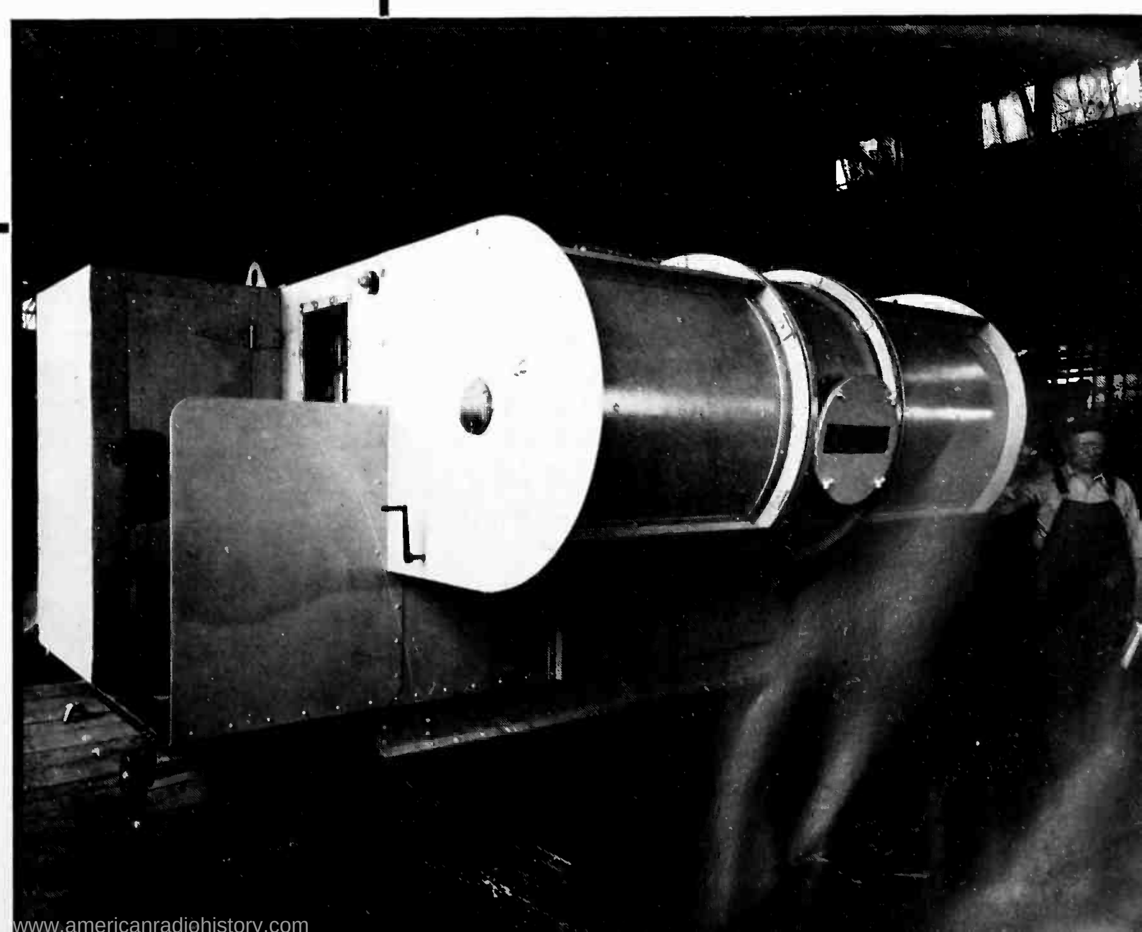
$$\lambda = 2d \sin \theta$$

where λ is the wave length, d is the distance between planes, and θ is the angle of reflection.

So far our discussion has dealt with the effect of a single crystal



Molecular crystal structure acts as a lattice for diffracting X-rays into patterns which reveal the identity of the crystal. Two typical lattice structures are shown at the right



This 400,000 volt Kelley-Koett industrial X-ray unit is one of the largest ever made. It finds extensive use in examining welds and structural members

Heater coils of a domestic appliance X-ray tested for proper spacing between turns

and is open to the criticism that most matter is not composed of single crystals but of large numbers grouped together with planes pointing in various directions. In reality, we cannot think of a crystal as a single set of parallel planes, but must remember that it represents groups of atoms arranged in a three dimensional lattice. By selecting different sets of atoms we can draw many different sets of parallel sheets capable of reflecting X-rays when at the proper angle. So, for example, among the innumerable crystals in a piece of steel there will be some here and there which will be set to reflect our X-rays.

One example of X-ray diffraction's solution of an industrial problem is the analysis of alpha and gamma iron. Pure iron at ordinary temperatures (alpha iron) has the crystal form known as body centered cubic. Pure iron at 1,000°C (gamma iron) changes its crystal form to that of the face centered lattice cube. These two forms of iron have different properties and are suitable for different purposes. The true explanation of the difference between the two crystal forms was only solved by X-ray methods.

A recent application is the analysis of electro-deposited metals. Metals deposited under different conditions show entirely different properties, such as hardness, brittleness, grain, etc. X-ray studies are responsible for determining the relation between conditions existing in plating processes and the resulting deposit.

Also, X-rays are capable of disclosing the various events occurring within crystals of metal subject to heat treatment, cold working, and strain long before the inter-crystalline boundaries are sufficiently affected to be visible under the microscope.

Construction of an Industrial X-ray Laboratory

Construction of an industrial X-ray laboratory may be divided into three sections, (1) generating unit, (2) X-ray tube housing, and (3) dark-room.

(1) Generating equipment is usually built in a unit containing high-tension transformer, control- or auto-transformer, X-ray tube filament transformer, rectifying mechanism, and operating dials and meters. Each X-ray concern has its own way of arranging the relative position of these pieces, but all operate on the same principle, and no one arrangement seems to have any great advantage over another.

(2) Leads from the generating unit carry the power to the X-ray tube which is located some little distance away and should be enclosed in lead except for a port to allow X-ray beam passage. The X-ray tube compartment is so suspended that it can be raised, lowered, and rotated to provide for taking radiographs at various angles.

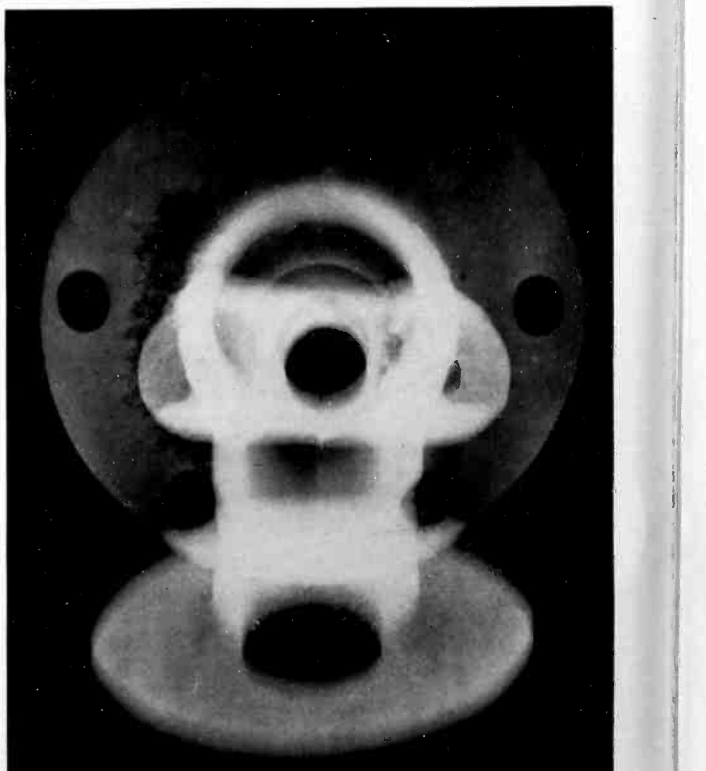
(3) Many plants already have a dark-room for use of the metallographic department. The same room may easily be rearranged or extended for development of films.

Once the type of equipment is selected, the most important consideration then becomes the arrangement of the units in a way not only to guarantee the highest efficiency and safety, but also to insure easy operation for the work to be done.

If the products to be examined are small, then the customary medical set-up may prove satisfactory. If the objects are awkward in size or shape, provisions must be made by changes in the tube-holder. Where it is necessary to radiograph large unwieldy objects the only solution is the building of portable apparatus.

Any X-ray laboratory design must cover precautions for the proper safety factors, both from the electrical and X-ray standpoints. Not only is the operating voltage high, but the danger to health from X-ray exposure is a serious problem demanding sufficient shielding and education of the workers. X-rays produce no physical sensation by which their presence can be detected, but small doses at short intervals exert a cumulative effect sometimes fatal. Not only is the primary beam injurious, but so also is the secondary radiation produced by its impact on matter, and the tertiary

A radiograph of a pump housing which showed shrinkage in the two flanges and the valve seat which, undetectable by the eye, might eventually cause a failure of the housing



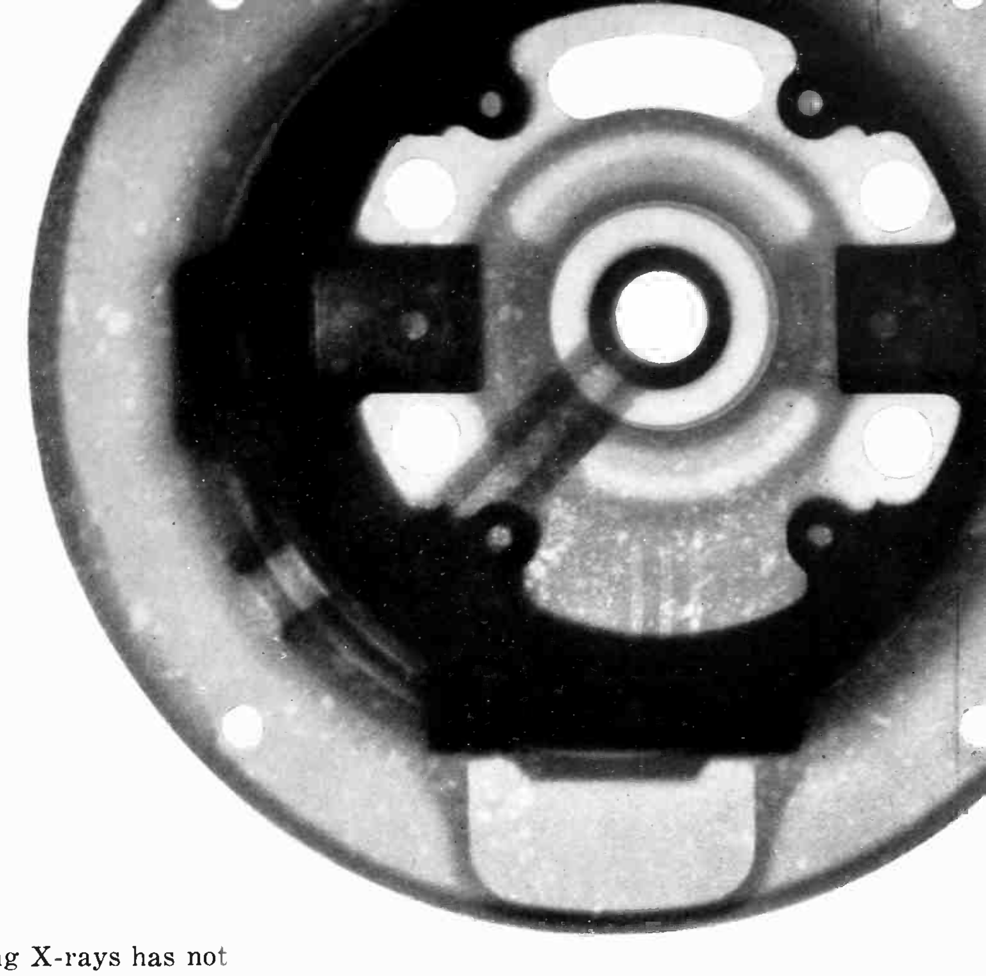
rays generated by the secondaries.

Another trouble-maker is the production of electrostatic disturbances by an X-ray machine in operation. This is specially bothersome when the apparatus is run near a laboratory using delicate electrical measuring instruments such as galvanometers and vacuum tube devices. Although easily remedied, it often causes no little annoyance before right shielding methods are adopted.

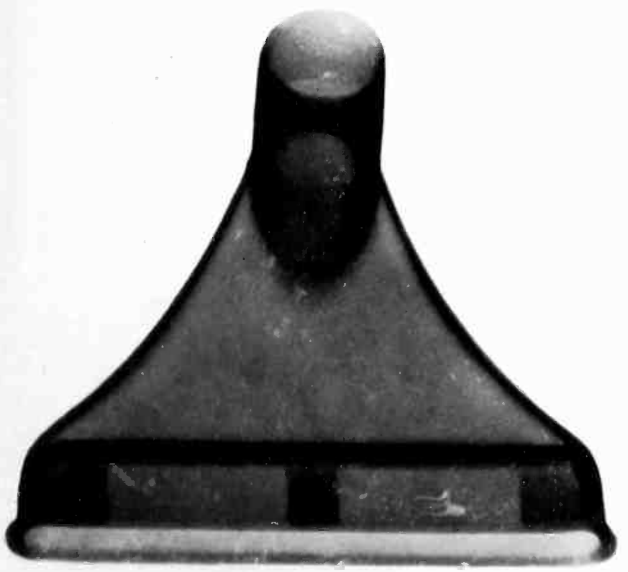
Prices given below are only approximate but are indicative of the cost. Apparatus using a voltage up to 75,000 volts will X-ray 0.2 inches of steel. It will cost approximately \$2,000. A 300,000 volt equipment will X-ray 4.8 inches of steel and will cost \$15,000.

An alternative to the construction of an X-ray laboratory of entirely new equipment has many times proved its value where a large expenditure is impossible. A laboratory built by the careful assembly of used equipment in most cases compares well in operation and quality of work with those which have the latest type of apparatus.

Used X-ray equipment cannot be compared to used automobiles, for only one or two small moving parts are subject to wear in an X-ray machine; the major portion is composed of transformers and wiring, and with proper treatment should last indefinitely. Nor is the principle of these used machines any different from the new ones, for the method of generating X-rays has not changed by an electron since Dr. W. D. Coolidge invented the hot-filament X-ray tube in 1916. What difference does exist rests mostly in a change from the rather cumbersome mechanical type of rectification to the silent, more compact tube.



X-ray inspection of a complex casting, the top casing of an appliance motor (note brush holders)



Vacuum cleaner attachment casting radiographed for porosity and imperfections

By exercising care and intelligence in the selection of parts, a serviceable equipment can be installed for a modest sum. The writer recently installed such an industrial X-ray laboratory, including darkroom for \$800 which new would have cost over \$3,000.

For most industrial work, where silence of operation and chromium-plate do not count for much, it is the writer's opinion that there is little difference, either in efficiency or durability, between new and used X-ray equipment, always provided, of course, the purchaser knows how to "shop."

This brief review indicates the place of X-rays in industry. In the order of their present development they are: (1) the radiography of industrial products for flaws and defects, (2) the X-ray study of crystal structure, and (3) the effects of X-rays on chemical substances.

To the industrial man discoveries in this field should have a particular significance, since the quality and durability of the products he manufactures are directly traceable to the behavior of the tiny particles which leave their shadows on X-ray films.

However, companies installing diffraction apparatus in their laboratories should not do so with the feeling that it will yield immediate cash returns, but rather that they are laying a foundation for a study which will bring a gradual improvement in their products during the years to come.

Chemical effects of X-rays to date have not been of great industrial importance, yet the subject seems to hold much promise. Certain it is that most of the results from irradiation of bio-chemical structures have been startling, to say the least. Irradiated eggs have hatched out all manner of queer monsters, fruit seeds so treated have borne fruit in a quarter the normal time, while a type of pollen-less lily has recently been bred and patented through application of X-rays. Last year the author discovered an unsuspected fermentation effect and chemical reduction of one acid to another as a result of irradiation of a well known food.

Being unassociated with any X-ray equipment concern, the author freely admits that there are places where the installation of such apparatus would be useless and economically unsound. Only investigation and deliberation can prove the invaluable aid rendered by radiographic examination or can demonstrate its superiority to other methods.

Radiographs illustrating this article were supplied by G. E. X-ray Corp. and Westinghouse X-ray Co.—Editor.

Pity the Parts

Set Makers Profit. Parts Suppliers Lose Money.

By HUGH H. EBY

Everyone in radio knows Hugh Eby as a pioneer manufacturer, president of his own company in Philadelphia. We are happy to present below his views on a matter that affects the entire radio industry. For our own attitude, see Crosstalk, *Electronics*, December, 1935.

UNDOUBTEDLY, 1935 was a good year for radio receiver manufacturers. More set makers made more money than for many years past.

On the other hand, it is equally evident that the trade still has an important step to take. For, while it is clear that radio manufacturers in general made substantial profit showings, it is also clear that most of their parts suppliers did not. Many made less than ever before. This is where the rub comes in. That is the danger point to the radio trade as a whole.

How could parts suppliers be expected to make money on volume controls supplied to set manufacturers at, say, 14c.; on resistors selling from \$12 to \$15 per thousand; on speakers under \$1—to quote but a few current prices?

While the percentage of failures among radio set manufacturers has shown a steady decrease since 1930, the number of parts manufacturers who have endured reverses has steadily mounted. Altogether this has an ominous sound. It is, in fact, the rumble of a distant drum, because it points to a weakening link in that chain of closely inter-related factors on which the ultimate success or demoralization of the radio trade depends.

To Make or to Buy?

Let our memories be refreshed on this point. Years ago it became apparent to set manufacturers that it was logical to buy certain radio components from outside specialty manufacturers. The parts manufacturer, having skilled engineers who concentrated their efforts on perfecting certain radio receiver components, became an authority in his chosen field. Serving many set manufacturers with his technical staff and special facilities, he offered a service unattainable otherwise.

Moreover, he effected great economies by spreading the cost so as to make it nominal for *each* set manufacturer. Of even greater importance, however, is the fact that with his plant facilities and equipment the parts manufacturer provided the necessary elasticity in production to tide the set manufacturer over the peaks and valleys of seasonable production. Obviously, then, the parts manufacturer became a tower of strength in emergencies—a mainstay of the whole industry throughout the year.

Now it must be remembered that a mainstay contributes to the support of something that might topple of its own weight—like the mast of a sailing ship. To ignore a mainstay in fair weather is bad—but to hack at it with a knife is madness, even with no storm coming. And for the radio industry as a whole hectic times are always in the offing. Television, for example, might affect the whole production and sales machinery of all manufacturers as if a hurricane had swept down. And yet the mainstay *is* being cut — hacked at by the slow insidious process of placing more and more emphasis on price.

This is not said in an attempt to condemn any reasonable price policy. The call for better parts at lower prices has developed manufacturing ingenuity to as high a degree as you will find in any industry in the world. Parts produced as a result of these advances have done much for radio. They have brought modern radio receivers within the reach of countless buyers who could not have purchased at higher prices. They have opened vast new markets in many directions.

The point is that the price situation has obviously been carried too far. Beyond the point of doing any further good it now looms as a potential factor for vast harm. It promises harm not alone to parts suppliers but to radio as a whole.

It is hardly necessary to recount some of the practices to which parts suppliers have been subjected in the race to obtain price concessions above and beyond those made feasible by the honest development of manufacturing facilities.

Sometimes they are forced to bid for the very right to make a product of their own design. Sometimes their blueprints or samples—products of skilled research and engineering genius—are given for competitive bids to price-cutting organizations (cunning imitators, merely) with no engineering staff and no overhead allowances for research and invention. Sometimes they are asked to assume patent infringement risks which the manufacturers, who will use the parts, hesitate to assume.

. . . . All of which has forced the parts supplier time and again to take orders on a "take it or leave it" basis—at prices which fail to cover his engineering and development costs and that do not permit of the quality which, in the long run, is going to be a mighty important factor in influencing public opinion regarding radios.

Now all of this is a general condition. All of us are aware of it and each of us is prone to place the blame elsewhere.

Is a set manufacturer to be blamed for taking advantage of lower prices when they are voluntarily offered, as they frequently are?

Is a parts supplier to be blamed for parrying cut price with cut price in a desperate effort to keep his factory wheels turning?

Suppliers!

Who Is At Fault? How Long Can This Go On?

Looking at things from a practical immediate standpoint, the answer is "No!" But all of us must admit that that is not an enduring answer. It can never lead to a satisfactory final solution.

For this fact is clear: *Unless parts suppliers can also make money they cannot continue to render the adequate service which has proved so essential, so economical to the industry in the past.* Unless they make reasonable profits the trade as a whole is bound to suffer.

From every practical standpoint, as previously related, parts makers have proved their value to set manufacturers in the past. And if they are to continue in the services their experience and set-up so eminently equip them to give, they must be dealt with accordingly. Beyond a certain point (which is clearly obvious to all concerned) it is dangerous to pit one against the other. And it is equally dangerous to regard price as the foremost consideration in dealing with them.

Which brings us squarely up to the matter of quality. And there comes a second rub—a second point of danger.

With more and more emphasis being placed on the price of radio components, it is obvious that only one thing could happen. Slowly but surely inferior parts crept into the picture. Slowly but surely, inferior radio sets found their way to the market.

Look backward a moment: Servicemen and parts jobbers were in existence before 1931, it is true. But not in the quantity they are today. The enormous growth of the radio servicing industry and the almost geometrical multiplication of parts jobbers was exactly coincident with the introduction of radios which were low in price but which were low on quality, too. In other words, even the ultimate consumer has been hurt in the price race because he has received less in the way of true quality than he has every right to expect considering the good names of the manufacturers involved.

There are 21,455,000 radio sets in use, and a lot of troubles can develop in so many complex units. But there are also 21,430,000 automobiles —yet the number of garage mechanics has actually decreased in the past five years. Nor has the increasing use of electrical refrigerators created a servicing industry comparable in any sense to the steadily mounting number of radio servicemen—a number variously estimated at from 25,000 to 75,000, and steadily growing.

And why, pursuing it further, cannot all radio sets be sold with longer guarantees? Consumers are asking this question. The glib answer that all radio troubles for which the retailer can be held responsible develop within ninety days or not at all leaves the consumer in a highly speculative frame of mind when he contemplates the guarantees upon the other mechanical and electrical devices belonging to him.

No Profits in a Good Name?

Whether we realize it or not, this is very likely to become a far more important consideration than it is today. Certainly there can be no lasting benefit to the industry from the continued sale of sets constructed of parts that have been built down to a given price rather than up to a quality standard. Carried beyond the depression into a period of renewed prosperity set selling of this sort can become distinctly dangerous. It means securing sales at the expense of the good name of the industry. And the preservation of a good name is not wholly a sentimental consideration. It is elemental common sense in any pursuit except those of the "clean-up-and-quit" variety.

If the present trend continues, how long before we hear this statement echoed by all important outlets, as we now hear it whispered here and there: "We find that the cost of parts replacement and servicing necessary to keep installment buyers satisfied through the completion of their payments is making increased inroads in our profits. More salesmanship is required of us nowadays to keep our customers satisfied."

This is not meant to imply that the set manufacturer is to blame for the present condition. Every parts supplier who has deliberately cut under a competitor's price to land an order, or who has under-bid on another's design, is equally to blame —and that probably includes all of us. In short, this portion of radio is the victim of upset economic conditions to a far greater extent than it has been victimized by any or all of those in it. The point is that, in the long run, set manufacturers also stand to lose if radio sets are not all they should be. And they are also the ones in the best position to take the initiative in strengthening the position of parts suppliers that their worth to the industry may be increased rather than curtailed. They are in the driver's seat.

A study of radio prices would indicate that the retail sales price of most sets is too low—lower in fact than needs be to insure the same volume of business and the same sales opportunities as now obtained. It is extremely doubtful that a slight increase in list prices would mean a single lost sale in the long run. And even a slight increase in prices paid to parts suppliers would spell the difference between profit and loss; between good parts and those of only mediocre quality; between honest engineering and price competition.

And it would likewise spell the difference between moderately good radios and fine, precision instruments which do not endanger or compromise the good name of the set manufacturer involved.

Class B and AB Audio Amplifiers

Output transformer design, better understanding of these more efficient amplifiers, approximate methods of determining load resistance and power output

By GLENN KOEHLER
University of Wisconsin

THIS article is written to aid in designing output transformers for class B and class AB amplifiers, to describe the manner in which these amplifiers operate and an approximate way of determining the load resistance and power output in the fundamental, and to give a way in which the distortion components may be determined approximately from the characteristic curves of the tube.

The Class B Amplifier

This type of power amplifier operates with such grid bias and d-c plate potential that there is practically no d-c plate current when the signal voltage is zero. It requires two tubes to give a wave form in the load that is nearly like the wave

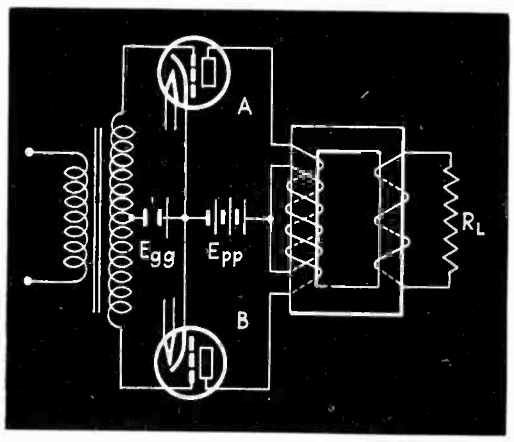


Fig. 1—Class B or AB amplifier

form of the input signal. The two tubes, working in a balanced push-pull arrangement, produce in most respects what a single larger tube will do when operating as class A. The only essential differences between these two is that in the class B amplifier the d-c plate current with no signal is small compared to the d-c plate current of a single class A tube which will give the same a-c power output. This results in higher efficiency for the class B amplifier. Because of the way in which the tubes are biased and because of the higher plate efficiency of the class B amplifier it is customary to drive the grids positive. Class A amplifiers are usually not driven positive but could be to some extent as long as the d-c operating conditions necessary to prevent distortion do not give rise to excessive heating of the plate.

The class B amplifier requires two primary windings on the output transformer to transfer the output power to the load. The two windings together serve the same purpose as a single winding of the same number of turns as each of the two for the single equivalent class A tube. Fig. 1 shows how the windings are related to each other. They are drawn in this way to make the analogy to the equivalent class A tube more striking. For a swing of the input voltage which is positive to the upper tube the winding in the plate circuit of this tube carries a-c towards the plate while the current in the other winding is practically zero. Then when the input voltage becomes positive with respect to the lower tube the winding in the plate circuit of that tube carries a-c toward its plate while the current in the other winding is practically zero. This gives the same results so far as the voltage induced into the secondary is concerned as would be obtained if the two class B tubes were replaced by an equivalent tube operated as class A and only one primary winding used to carry a-c in alternate directions for the two halves of the input cycle. The graphical analysis of Fig. 2 illustrates the currents through each of the two windings as derived from an ideal dynamic characteristic of the class B tubes as a unit. The dotted line current waves on this graph illustrate currents whose effects are practically balanced out in the magnetic medium of the transformer. Actually it is never possible to obtain such an

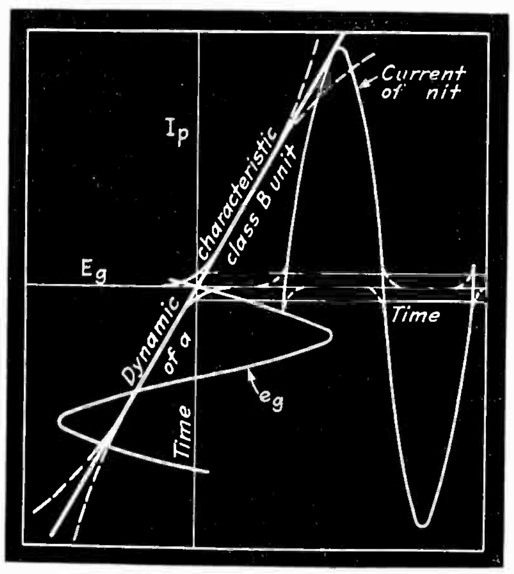


Fig. 2—Ip-Eg dynamic characteristics of Class B unit

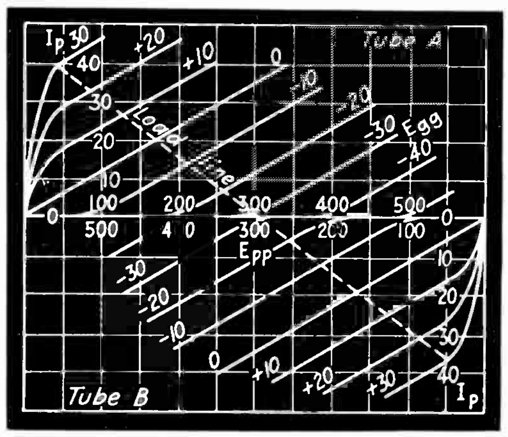


Fig. 3—Composite Ip-Ep characteristics of Class B unit

ideal dynamic characteristic for a class B unit. If the load resistance is too high the I_p-E_g characteristic will flatten off at the two extremes of the grid swing as shown by the dotted lines and if too low they will follow the dashed lines. Distortion will result in either case.

For an ideal transformer, if N is the ratio of the turns of one primary winding to the secondary winding, the load resistance R_L is transferred as a resistance $R_L N^2$ to the two class B tubes as a unit or to the single equivalent class A tube.

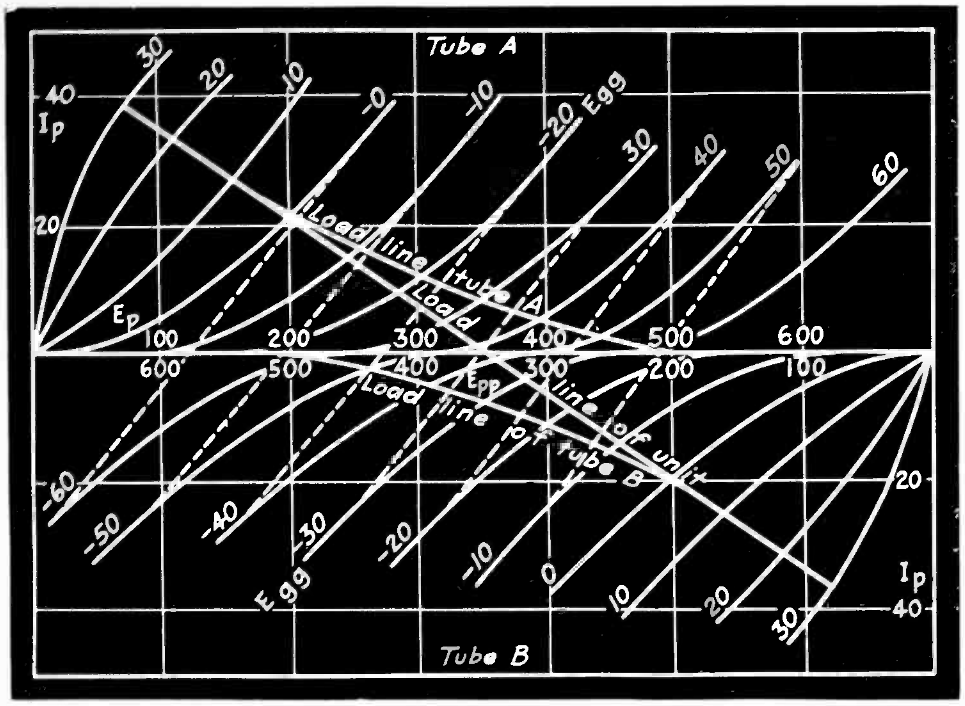


Fig. 4—Composite characteristics of Class AB amplifier

This is the impedance that determines the dynamic characteristics of the unit and the power output of the unit and not the so-called plate-to-plate impedance. By analogy to the equivalent class A tube the power in fundamental is

$$P_o = \frac{\mu^2 E_g^2 R_L N^2}{(R_L N^2 + r_p)^2}$$

in which μE_g is the equivalent generated voltage and r_p is the internal impedance for the class B unit. The tube factors μ and r_p have the same significance for the class B unit as they do for the single equivalent class A tube. Because the class B tubes are driven over a much greater range these factors vary some over the range of operation. This is especially true of r_p. The factors μ and r_p may be measured by direct methods for several values of d-c plate and grid voltages and the average taken. These constants may be also obtained from the characteristic curves of the tube as follows:

The factor r_p is the reciprocal of the slope of the straighter portion of the I_p-E_p curve at some constant value of grid potential. Since the I_p-E_p curves do not all have the same slope the average of several curves should be determined. Usually it is sufficiently accurate to evaluate r_p from an I_p-E_p curve which corresponds to a d-c grid potential equal to the r.m.s. value of the a-c grid potential above the grid bias potential E_{gg}. Since $\mu = G_{pg} r_p$, where G_{pg} is the transconductance of the tube, it is necessary to evalute G_{pg} to get μ. The tube factor G_{pg} is the slope of a line which coincides with the greater portion of the I_p-E_g characteristic for a particular value of plate potential. Because the slopes of all such lines for different values of E_p differ, the average must be taken. When the I_p-E_g curves are not available G_{pg} may be evaluated from the I_p-E_p curves by dividing the change in plate current by the change in grid potential which produces the change in plate current when reading such changes along a constant plate-potential line.

Distortion

The expression for the power output of the class B unit gives only the power in the fundamental. The expression is quite accurate for tubes operated with negative bias like the 45, but not for tubes like the 46 operated only in the positive region of the grid swing. There is no simple expression from which the distortion power may be calculated. Distortion will result when the sum of the currents in the two windings of the primary do not follow a sine wave. This means that the current in one primary need not be a sine function as long as the current in the other winding is of the proper character to make the sum of the two a sine wave. For low values of input voltage the distortion is due to the upward curvature of the dynamic characteristic. Distortion of this nature is largest when the load impedance R_L^2N to the class B unit is smallest. For a high input voltage the distortion decreases at first with increase in load resistance, reaches a minimum and then increases when the downward curvature of the dynamic characteristic becomes excessive. This means that there is some value of load resistance that results in minimum distortion for a given input voltage. This value of load resistance does not generally agree with the value which will result in maximum power in the fundamental for a fixed input voltage, nor with the value which will result in the maximum possible power for a given amount of distortion. It is possible to predict from

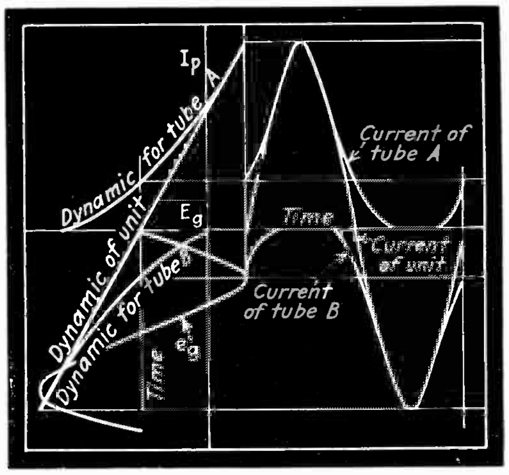


Fig. 5—Ip-Eg dynamic characteristics of Class AB amplifier

the characteristic curves of the tubes the load resistance which gives the maximum possible power output for a limited amount of distortion. The procedure is exactly the same as for the equivalent class A tube. From a given load line (Fig. 3) the dynamic characteristic of I_p versus E_g can be determined as for a class A tube. Then it is possible to determine the distortion fairly accurately.[1] The distortion will not be serious if the load resistance R_L^2N is such that the load line crosses the I_p-E_p characteristic for the peak swing of the grid voltage above the knee of this characteristic.

Class B Output Transformer

The above theory gives the conditions, with reference to the equivalent impedance of the source, which must be considered in the design of the output transformer. The class B unit is replaced by a single equivalent Class A tube. The equivalent source is a generator of μE_g volts with an internal impedance of r_p ohms. From this equivalent source, power is supplied to the load through only one of the primary windings. Hence the inductive reactance, ωL_m, of each primary winding, with secondary open, must satisfy

$$\omega L_m = \frac{R_L N^2 r_p}{(R_L N^2 + r_p)\sqrt{\left(\text{anti}\log_{10}\frac{db\ \text{loss}}{20}\right)^2 - 1}}$$

where the db loss is the loss in decibels allowed at the lowest frequency over the losses in the transformer at medium frequencies. The d-c resistances of the windings should be added to R_L for the secondary and r_p for the primary. The ratio of turns, N, of one primary winding to the secondary winding must be such as to transfer the load resistance R_L to whatever resistance is necessary for the Class B unit. The load resistance for a given amount of distortion is determined largely by experiment.

Since only one primary winding carries current at a time, it is good practice to interspace the primary windings with each other so they will have the same resistance and will also have the same leakage inductances with respect to the secondary. The two primary windings should also be interspaced with the secondary winding and preferably be placed between the two halves of the secondary. This interspacing is necessary to improve the high frequency response.

The Class AB Amplifier

The class AB amplifier operates with grid bias intermediate to that of class A and class B and is so driven that a-c plate current in each tube flows for more than 180° and less than 360° of the input cycle. Because the grids are driven positive this amplifier requires driving power. The same analogy to one equivalent class A tube to replace the two class AB tubes may be carried out similarly as it was done for the class B amplifier. In the case of the class B amplifier the unit acts as a source of μE_g volts having an internal resistance r_p ohms. In the case of a push-pull class A amplifier, if put on a unit basis, the voltage of the equivalent generator would be μE_g and the internal impedance $r_p/2$ ohms, if analyzed on the basis of a single class A tube which would be coupled to the load resistor through a transformer having a ratio of primary turns on each primary to the secondary turns equal to N. Consequently, for a class AB amplifier, since each tube supplies more power to the load on one-half cycle of the input than on the alternate half-cycle, the internal impedance of the equivalent generator is r'_p somewhere between r_p and $r_p/2$.

The power output in the fundamental for the class AB unit is

$$P_o = \frac{(\mu E_g)^2 \ R_L N^2}{(R_L N^2 + r'_p)^2}$$

in which R_L is the load resistance and N is the ratio of the turns of one primary winding to the secondary turns. It is assumed that the transformer losses are negligible or included as a part of $R_L N^2$.

To evaluate r'_p we draw the composite I_p-E_p characteristics obtained by adding algebraically the I_p-E_p curve of tube A for a grid voltage of $E_{gg} + X$ volts to the I_p-E_p curve of tube B for a grid voltage of $E_{gg} - X$ volts. The quantity X may be either positive or negative. These composite characteristics are the dotted lines of Fig. 4. It is assumed here that the E_p-I_p curves give straight line composite characteristics. If this were true there would be no distortion. Since the distortion is only a few percent for a good amplifier these composite characteristics are nearly straight lines for any tube that performs well in a class AB amplifier. r'_p is the reciprocal of the slope of a composite characteristic. When these characteristics do not all have the same slope, r'_p should be averaged from several values.

Since $\mu = G_{pg}/G_p$ it may be evaluated from E_p-I_p characteristics by evaluating the transconductance G_{pg} and the plate conductance G_p (the slope of the straighter part of an I_p-E_p curve). G_{pg} is the ratio of a change in plate current to the change in grid voltage which produces the change in plate current, when working along a constant plate voltage line. μ may also be evaluated from the composite characteristics by determining G'_{pg} from the composite characteristics and dividing by G'_p the slope of a composite characteristic.

In Fig. 4 is shown the load line for each tube as compared to the load line of the unit derived as follows: Constant E_p lines are drawn through the intersections of the composite characteristics and the load line of the unit. Where each of these vertical lines intersects the I_p-E_p curves from which the composite characteristics were derived locates a point on the load line for each tube.

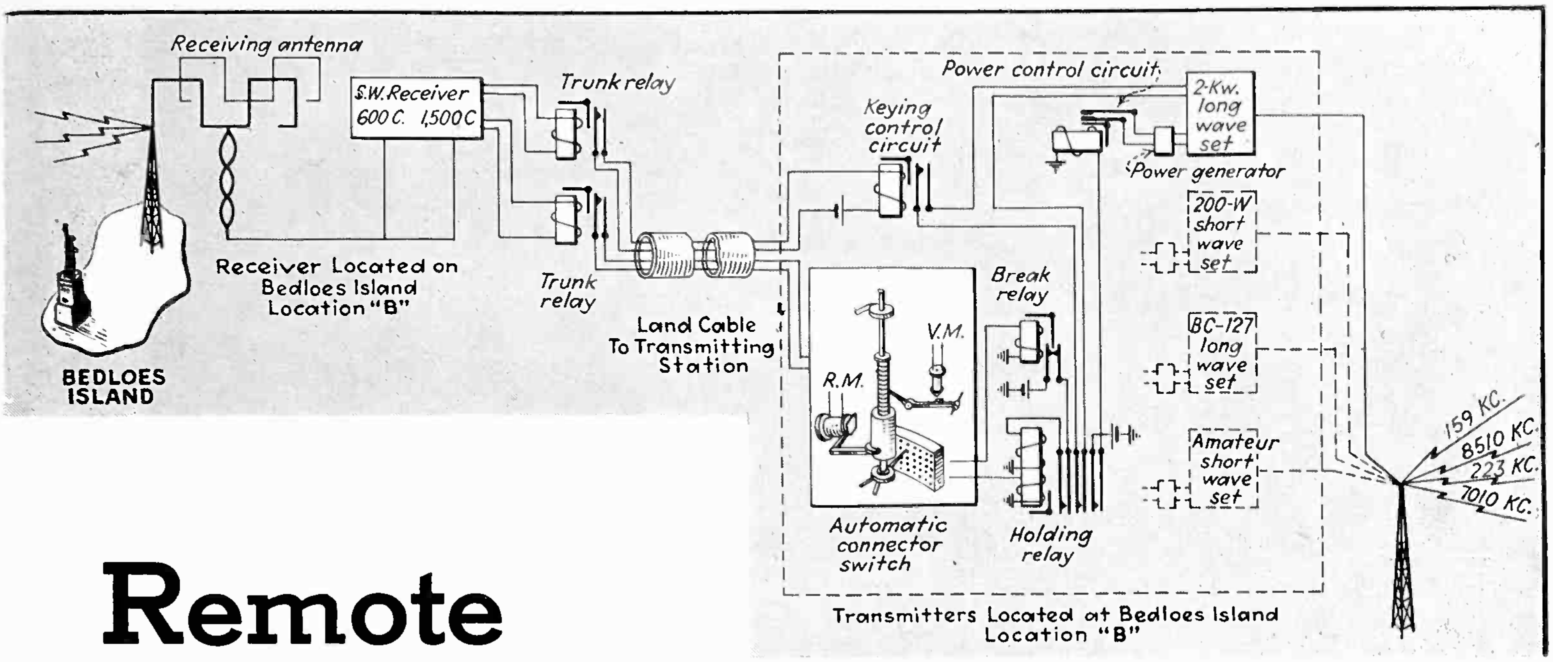
The dynamic I_p-E_g characteristics can be derived from the load lines and composite characteristics. The dynamic I_p-E_g characteristic of the unit is obtained by plotting the values of I_p where the unit load line crosses the composite characteristics against the corresponding values of E_g. The individual dynamic characteristics are obtained by plotting the value of I_p where the individual load lines cross the I_p-E_p curves against the corresponding values of E_g. A typical set of dynamic I_p-E_g characteristics are shown in Fig. 5. The current of the unit shown in Fig. 5 is the current that would be delivered to one primary winding by an equivalent single class A tube.

Class AB Output Transformer

The general design of the output transformer for a class AB amplifier is the same as for a class B amplifier. The quantity r'_p is substituted for r_p in the expression from which the impedance of the transformer is determined to give a particular db loss at the lowest frequency. r'_p is the reciprocal of the slope of a composite characteristic. r'_p is smaller than r_p the plate resistance of the tube. For class AB, r'_p is somewhere in between r_p and $r_p/2$.

When the interspacing is employed in the transformer to improve the high frequency response it is preferable, if possible, to place the two primary windings between the two halves of the secondary. The reason for this is that the currents in the primary windings are not the same for all instants of time. Unless these two windings have nearly the same leakage inductances with respect to the secondary, some distortion will be introduced into the output.

[1]Proceedings of I.R.E., Vol. 19, No. 8, p. 1481.



Remote Control via 5 Meters

Across the main New York harbor ship channel, a 5-meter remote-control link enables Signal Corps to select, stop and start one of several radio transmitters

SINCE Governors Island is the headquarters of the Second Corps Area of the Army a great amount of message traffic originates at this important military post. As much as possible of this traffic, and especially that to Army transports at sea, is handled by Signal Corps radio.

From the earliest days of Army radio the transmitters for this post have been at Fort Wood on Bedloes Island. Fort Wood lies approximately southwest of Governors Island and distant about 1½ miles. Between the two islands passes the main ship channel of the harbor. Years of sad experience with submarine cables being fouled and broken by dragging ship anchors led to the establishment of the radio link pictured here.

The transmitters at Fort Wood are four in number, operating at different frequencies, and with rated power outputs ranging from 200 watts to 2 kw. The problem was to permit the operators on Governors Island to select and start the desired transmitter, and, indirectly to key it. The Fort Wood stations could, then, be essentially non-attended.

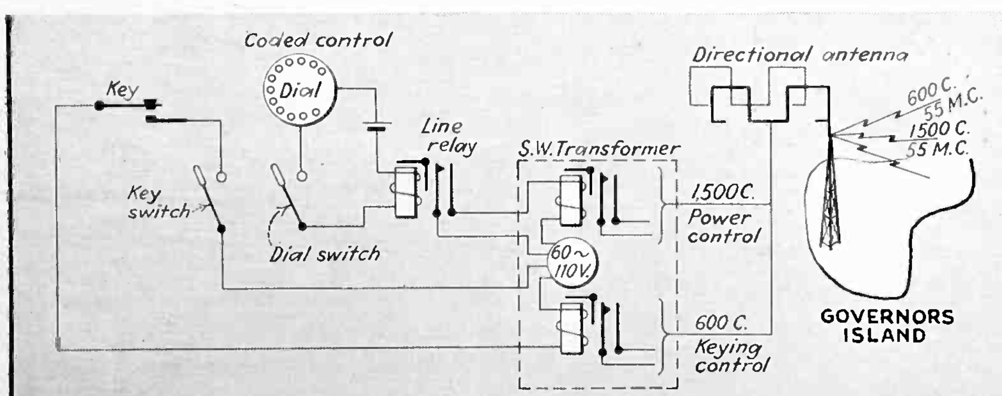
The desired selective control feature seemed to indicate something along the principles of automatic telephony, and the co-incident availibility of a five meter transmitter and some dial switchboard equipment started the project.

The five meter transmitter was remodeled to permit modulation at either 600 or 1,500 cycles obtained from electrically driven tuning forks. Keys to select the modulating frequency, and a telephone dial to provide the coded interruptions of either tone, were built into a small cabinet which is located on the operating desk at Governors Island.

At the Fort Wood end of the channel a conventional super-regenerative receiver is employed. Relays in place of the usual head-set or loudspeaker control an automatic selector switch of the step-by-step type and from that point the operation is similar to the trunk and line selecting system of the automatic telephone.

At the inception of this idea it was proposed to key the transmitters over this five-meter channel. It was found, however, that there were several disadvantages in doing this. In the first place, the receiver at Fort Wood does not have suitable charac-

[*Continued on page 64*]



Control Transmitter Located at Receiving Station, Governors Island Location "A"

Steel-clad Tube for Schools

A 10-kw. mercury tube of the metal-enclosed type which can be taken apart and put back together by students to learn how large rectifiers for communication and industry are made—and how they operate

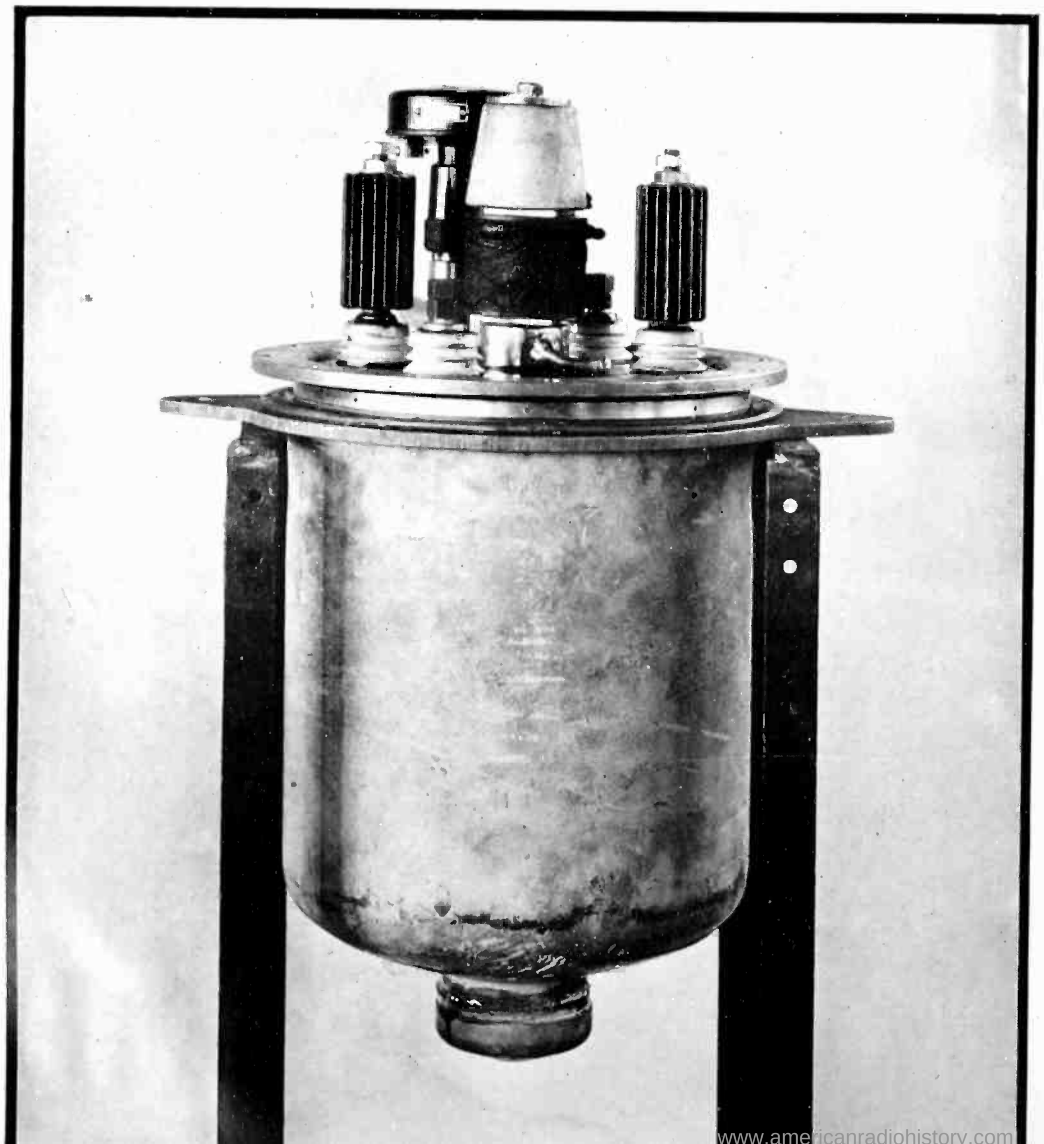
By S. R. DURAND

MANY colleges and universities have become aware of the demand for well-trained engineers in the electronic field and are endeavoring to equip their laboratories with electronic devices so that they may offer practical as well as theoretical courses on this highly important subject.

The problem of selecting vacuum tube apparatus for laboratory use is difficult to solve because of the high cost of most electronic devices. Small glass-enclosed radio tubes can be purchased or made in a school laboratory for little expense, but their use is confined almost entirely to communication subjects. Larger size hot-cathode power tubes are available, but the high cost of these tubes practically prohibits their use for experimental purposes. Steel tank power tubes of several hundred or thousand kilowatts capacity are far too expensive for a school laboratory, so that, unfortunately, the study of this type of very important electronic device is entirely overlooked. As a result of this situation most courses involving electronic tubes are confined to the use of glass tubes in the communication field, and the application of steel tubes in the power field is completely neglected.

Steel-enclosed tubes have attained such an important place in the power field today that several professors from various universities have appealed recently to manufacturing companies for assistance in preparing courses on this subject. Allis-Chalmers engineers responded by offering to build for educational institutions a model steel-tank tube which would be almost an exact replica of one of their large power tubes. Model tubes of this kind are frequently used to solve research problems and to obtain preliminary data for the design of power tubes of several thousand kilowatts rating, so that their value can be fully appreciated. It is believed, therefore, that similar model tubes in a school laboratory would be of real value in experimental and research studies, and would enable professors to acquaint their students with the design, forming, and actual operation of this important electronic device.

Model demountable steel mercury-arc rectifier



The typical model steel power tube shown here is about one foot in diameter, and weighs only one hundred pounds. It is rated at 10 kw., and can be operated up to 3,000 volts d.c. It can be completely disassembled, modified in various ways, and reassumbled by students in the laboratory. It can be evacuated within a short time by means of standard vacuum pumps. Since excitation of this mercury arc tube is accomplished by means of an auxiliary arc instead of with a hot-cathode filament, the life of the tube is unlimited.

Model tubes of this size can be provided with six anodes for single-phase, two, three, four and six-phase rectification of an a-c power supply system. This enables studies to be made of various types of rectification circuits, and of the efficiency, regulation, arc drop loss, power factor, and other characteristics of

[*Continued on page 29*]

View of the Inductotherm during the test transmission which was heard in Washington. No changes were made in the machine except to open the plate circuit for insertion of the automatic key seen on the stand at the right. The radio-frequency energy was radiated from overhead power lines after passing back through the base outlet seen just above the table leg behind the wastebasket. The call letters NDA1 were assigned to the machine for this test

Interference Source Discovered

Professor Mimno of Harvard tracks down mysterious 60-cycle signals which have interfered with commercial services from 8 to 28 mc. Source proves to be short-wave therapeutic apparatus with several hundred units in use in the United States.

ON December 13, 1935, the Federal Communications Commission requested the assistance of the Cruft Laboratory, Harvard University, in locating the source of a mysterious interference which was disrupting radio services in the region from 8 to 28 megacycles. Five days later the Cruft sleuths had found the source of the interference and had "brought it back alive," by obtaining one of the interfering machines for further tests in the laboratory.

The interference being sought was sixty-cycle in character, and sounded like a self-excited oscillator with raw a.c. on the plate (this was later found to be the case). It appeared simultaneously at various spots from 8 to 28 megacycles, apparently at random, and was common around 11.5, 12, 12.5 and 18 megacycles. It would jump frequency, perhaps 10 to 100 kc., in an utterly haphazard manner. The signals were usually heard from about 9 a.m. to 8 p.m., e.s.t. They were quite strong at times and tuned about as sharply as a high-speed telegraph station. The signals had been picked up in Canada, England, Central America and all over the United States. Interference conditions had been particularly bad since the first of October, 1935, and the Navy Department and Communications Commission had been unable to trace the trouble.

In view of the widespread range of the interference, the Cruft investigators found it hard to believe, at first, that the signals were not emanating from an actual transmitter with a good antenna. However, as many as twelve such signals were heard simultaneously, and when cathode ray patterns showed them to be on several different 60-cycle power nets, it seemed unlikely that such wholesale interference was being maliciously transmitted from so many different points.

An investigation at large Boston hospitals found no device which would cause the trouble, but a machine called the "Inductotherm," used for giving artificial fevers, was located at the Dillon Field House at Harvard University. It was brought to the laboratory for further tests after cathode ray patterns indicated that the culprit had been found.

Investigation disclosed that the device is a T.P.T.G. push-pull oscillator with raw a.c. applied to the plates. The total input is about 700 watts. The grid coil and condenser are fixed, but the whole tuned plate circuit consists of a flexible rubber cable about 12 feet long, which is coiled about the part of the body to be heated. Naturally any movement of the patient causes random changes in the frequency. Except for the use of the radio-frequency chokes necessary to insure oscillation, no effort has been made in the design to keep radio-frequency currents out of the power lines. Tests show that large amounts of radio-frequency energy do find their way into the power lines and may be radiated from them.

Since cathode ray observations showed multiple path, and therefore long distance transmission, it was considered advisable to conduct tests to get positive evidence that the signals radiated by the machine in normal use carried beyond the skip zone. Arrangements for such tests were made, in cooperation with Dr. A. H. Taylor of the Naval Research Laboratory at Bellevue, D. C. The borrowed machine was set up in a residence where the a.c. came in on overhead lines, and an automatic key was inserted in the plate lead. The keyed signals, on 11.8 Mc., were heard at the Naval Laboratory at Bellevue, D. C., with good signal strength although they were hardly audible several miles from the source.

It seems probable that the long distance disturbances could be eliminated by suitable filters in the power leads. The local interference, which comes from the large tank coil radiation, would probably require a shielded room to stop it. The "Inductotherm" has been on the market over a year, and it is estimated that there are two or three hundred of them in use in the United States. Many of them are used by college gymnasiums for treating injuries to athletes, and the sudden increase in interference noticed this fall was probably due to the start of the football season.

The search at Cruft Laboratory was under the direction of Professor Harry Rowe Mimno, and was carried out in his absence by H. Selvidge, J. A. Pierce and Paul B. King, Jr., research workers at Cruft Laboratory.

Loud Speaker Design

The first of several articles covering the subject matter of a Colloquium on "Recent Developments in Applied Acoustics" led by the author at the Massachusetts Institute of Technology during December, 1935

By FRANK MASSA, M. Sc.
RCA Manufacturing Company, Inc.
Camden, New Jersey

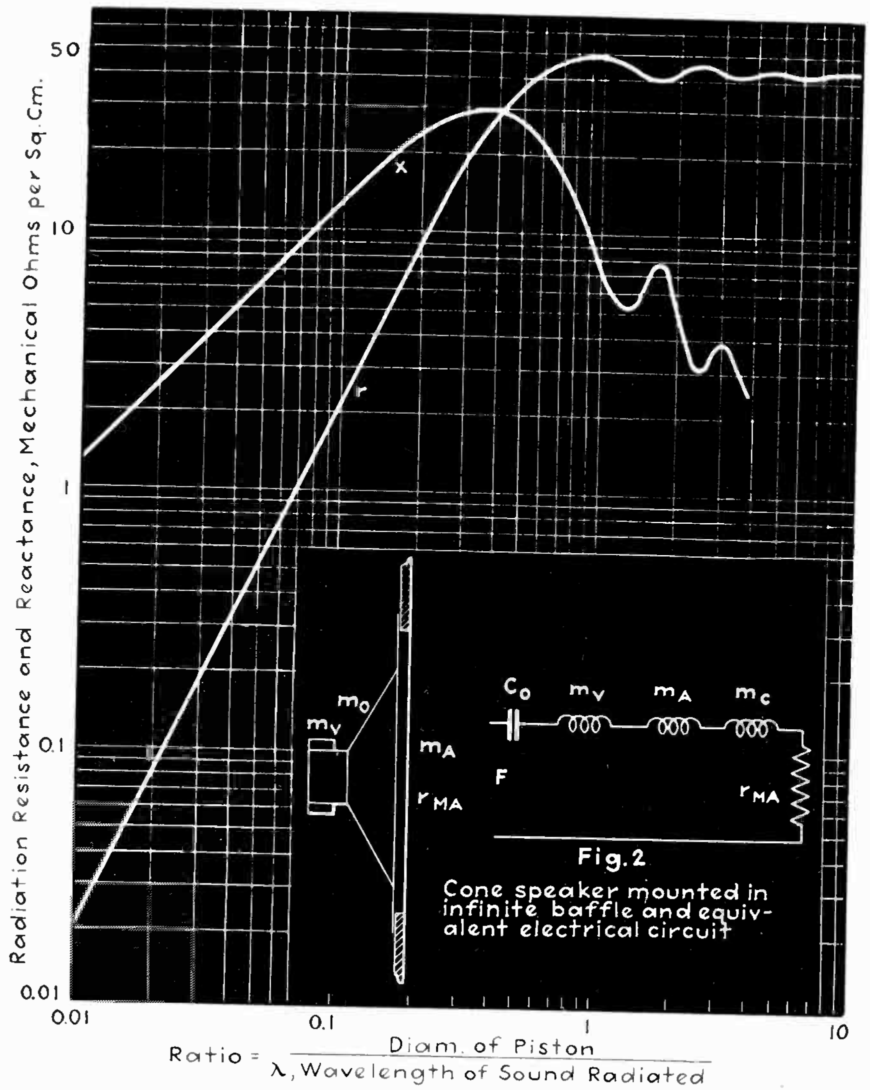


Fig. 2
Cone speaker mounted in infinite baffle and equivalent electrical circuit

Fig. 1. Radiation resistance (r) and reactance (x) of a piston mounted in an infinite baffle

SINCE the loud speaker has found widespread commercial application, there is need for more emphasis regarding the fundamental principles which determine its performance. While it is true that it is still impossible to take into account every variable in the design of a loud speaker (such as, for example, the mode of vibration of a conical diaphragm at the higher frequencies), there are many parameters which can be controlled. By an intelligent correlation of these facts, it is possible to predetermine such things as efficiency and frequency response with a fair degree of accuracy.

It is the purpose of this paper to analyze the loud speaker in terms of electrical engineering terminology and to show the quantitative relation between the various physical components and the resultant performance.

The dynamic or moving coil loud speaker consists of a diaphragm fastened to a coil of wire which is mounted in a radial magnetic field. The driving forces for the diaphragm result from the interaction of the voice coil currents and the air gap flux.

(a) *Flat Baffle Speaker at Low Frequencies*—First, let us consider the behavior of a dynamic speaker which radiates directly into free space. The speaker will be assumed mounted into an infinite plane wall so that any interference from the back radiation can be neglected. The driving force generated in the voice coil, in addition to overcoming the mechanical impedance of the vibrating system, must also overcome the reaction of the air load on the cone.[1] The character of this radiation impedance is shown in Fig. 1.

It can be seen that for a piston whose diameter is smaller than one-half wavelength, the radiation resistance per unit area increases both as the square of the frequency and as the area of the disc. For diameters greater than one-half

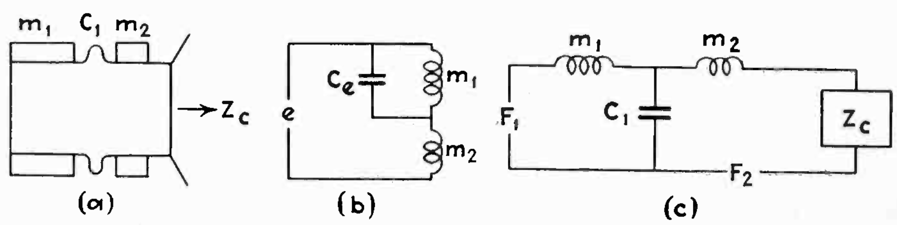
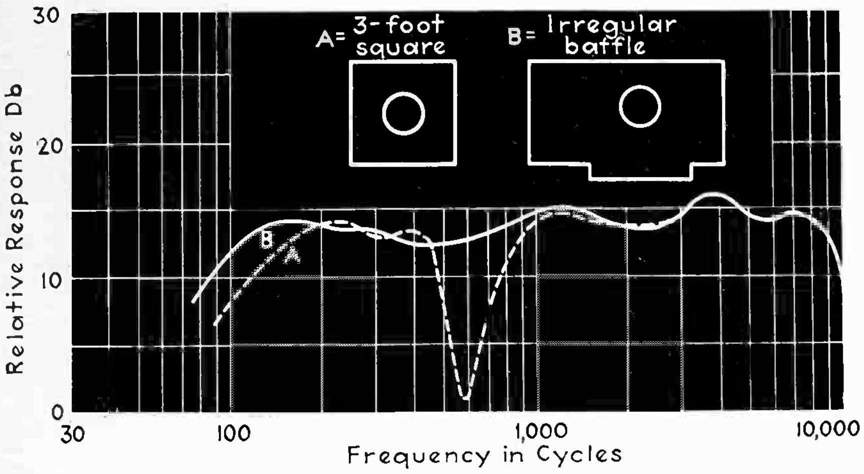


Fig. 3. (a) Construction of double voice coil drive for a dynamic speaker
(b) Electrical connection to the voice coils
(c) The equivalent circuit of the mechanical system



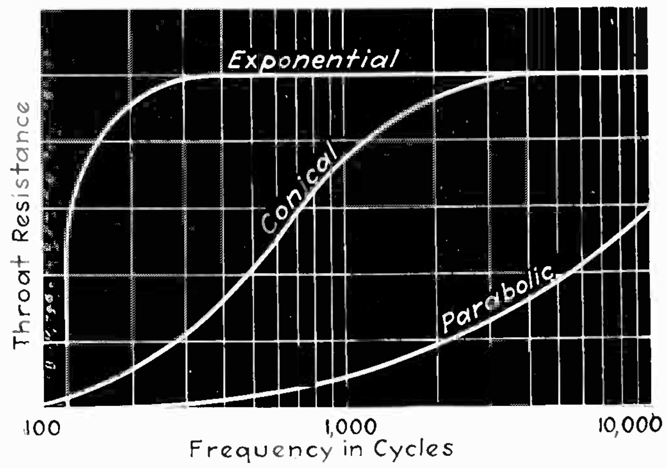


Fig. 4. Response curve of a double voice coil speaker taken at a distance of 10 feet. Figure 5 (right) Infinite horns having same throat areas and same areas at distances along their axes equal to 100 times the throat diameter

wavelength, the resistance becomes approximately constant.

At low frequencies the dynamic speaker may be assumed to act as a rigid piston and the equivalent electrical circuit for this condition is represented in Fig. 2.

The velocity of the cone is given by

$$u = \frac{F}{r_{MA} + j\left(\omega m_o - \dfrac{1}{\omega C_o}\right)} \text{ cm./sec.} \quad (1)$$

where:

$F = Bli/10$ dynes (2)
B = air gap density in gausses,
l = length of wire in voice coil in cms.,
i = voice coil current in amperes.

$r_{MA} = rA$ (3)
r = resistance obtained from Fig. 1.
A = area of cone in sq.cms.

$m_o = m_v + m_c + m_A$ (4)
m_v = voice coil mass in grams,
m_c = cone mass in grams,
m_A = effective mass of air load in grams.

$m_A = x_{MA}/\omega$ (5)
$\omega = 2\pi f$; f = frequency in cycles per sec.

$x_{MA} = xA$ (6)
x = reactance obtained from Fig. 1.

C_o = compliance of cone suspension in cms./dyne.

The acoustic power output of the cone is equal to

$$P = |u|^2 r_{MA} \cdot 10^{-7} \text{ watts} \quad (7)$$

u = absolute value of the cone velocity computed from Equation 1.

The maximum amplitude (from the mean position) of the cone moving with an r.m.s. velocity u is equal to

$$d_{max} = \frac{1.41\, u}{\omega} \text{ cms.} \quad (8)$$

The above equations, together with the information in Fig. 1, permit a quantitative consideration (at low frequencies) of all the factors connected with the acoustical design of a dynamic speaker. By a proper adjustment of the various constants of the system, it is possible to secure optimum performance at minimum cost.

From Fig. 1 and eq. (7) it is obvious that to secure constant output from a cone mounted in an infinite baffle, throughout the range of frequencies for which the cone diameter is less than $\frac{1}{2}\lambda$, the velocity of the cone must vary inversely as the frequency. If the mass is the controlling factor in the system over this range, the condition for constant acoustic output will be satisfied.

The effect of C_o, the combined compliance of the centering support and the outer suspension, can be seen from an examination of eq. (1). At the frequency for which $\omega m_o = 1/\omega C_o$, the cone will resonate and move through large amplitudes, resulting in large acoustic output. Below resonance, C_o becomes the controlling factor and the acoustic output decreases rapidly. If uniform output is required, it is important to keep the resonance of the cone below the lower frequency limit desired for the speaker. Sometimes the resonance peak is purposely placed near 150 cycles to secure the impression of good low-frequency output from a reproducing system which is actually lacking in low-frequency performance.

From a consideration of the equivalent circuit of the dynamic speaker and from the variation of radiation resistance with diameter, it follows that for a fixed driving force the efficiency at low frequencies is independent of the cone area (assuming the effective mass of the system is proportional to this area). However, as the cone is made larger, it is possible to increase the amount of wire in the voice coil in the same proportion, which will result in a larger driving force and better efficiency. Also, the amplitude through which a cone must move for a given output varies inversely as its area and for large low-frequency outputs it is impractical to provide for the large amplitudes that would be required for the smaller cones.

(b) *Flat Baffle Speaker at High Frequencies*—The desirable features for good low-frequency performance (large cones and heavy voice coils) are both disadvantageous in the high-frequency range. It was shown in Fig. 1 that at frequencies above which the cone diameter $= \frac{1}{2}\lambda$, the radiation resistance becomes approximately constant. When this happens the output will steadily decrease with rising frequency if the system remains mass-controlled. The larger the cone diameter, the lower will be the frequency at which this takes place. For a 12″ cone the limiting frequency is about 750 cycles, and for an 8″ cone it is about 1,000 cycles. Thus it becomes evident that an infinitely rigid cone, the condition represented in the equivalent circuit, would be undesirable at the high frequencies.

To keep the output from falling off at the higher frequencies, it is necessary to prevent the mechanical impedance of the vibrating system from rising. This may be accomplished by breaking up the cone into several sections by means of corrugations. The effect of these corrugations is to reduce the effective mass, m_c, in Fig. 2, throughout the mid-frequency range, with the result that the cone output will not fall off in this region.

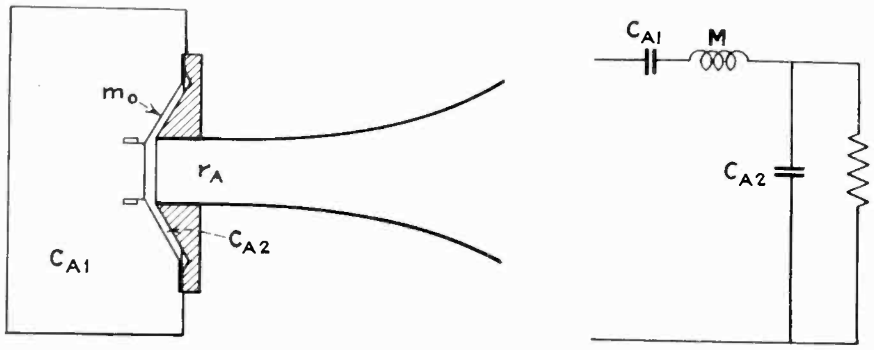


Fig. 6. Horn loud speaker and equivalent electrical circuit

At still higher frequencies, the voice coil mass, m_v, becomes the controlling factor in determining the impedance of the vibrating system. When this takes place the acoustic output will again fall off with further increase in frequency. In conventional speakers, this occurs in the vicinity of 3,000 cycles. By substituting aluminum in place of copper in the voice coil, the mass for a given length and resistance of wire will be reduced with a corresponding improvement in the high-frequency performance.

If the range is to be further extended, it is necessary to reduce the voice coil mass still further at the higher frequencies. This has been successfully done by breaking up the voice coil into two sections[2] which are separated by a compliance C_1, as shown in Fig. 3.

At the low frequencies the condenser C_c is a high impedance and the total current flows through both sections of the coil. The compliance C_1 also offers a high impedance at low frequencies so that the unit behaves as a conventional single coil. At the higher frequencies the condenser by-passes all the audio power to the small section of the coil and at the same time the compliance C_1 acts to prevent the large portion of the coil from vibrating with the corresponding reduction in coil mass.

A loud speaker employing this new type of voice coil construction has permitted the high-frequency range to be extended by a full octave over the conventional voice coil type. Of course, it is also possible to cover a wide frequency range by employing two or more separate speakers, each designed to operate efficiently over different portions of the desired total range.

(c) *Finite Baffles* — The above discussion has been concerned with speakers mounted in an infinite wall. In practice, this condition is not always realized, so it is found that the low-frequency performance is determined by the size and shape of the baffle in which the speaker is mounted. When the baffle size is relatively small compared with the wavelength of the sound being generated by the loud speaker, the radiation from the rear interferes with the sound which comes from the front, causing a reduction in acoustic output. If the diameter of the baffle is made equal to about one-half wavelength for the lowest frequency to be reproduced there will be no loss in output due to interference.

If a loud speaker is mounted in a symmetrical baffle, it will be found that when the difference in path from the front and back of the cone to the point of observation equals a wavelength, interference will result and a reduction in output will occur. If the baffle is made irregular, the path differences vary and no pronounced interference dip results.

To avoid the use of a baffle, the speaker may be enclosed in a box so that only radiation from the front takes place and thus no interference can result. The enclosure behind the cone, however, acts as an added stiffness to the suspension system and the volume of the space must be large enough to prevent the cone from resonating at a high frequency. The larger and heavier the cone, the larger must be the box. For rather large cones, the size of box may become too large to be practical if real low-frequency cut off is desired.

In the cone type speaker discussed above the efficiency is inherently low except at resonance. The low efficiency results from the fundamental necessity of using a relatively heavy diaphragm to drive a light sound medium. The average radio loud speaker is less than 5 per cent efficient except at its resonance peak.

To improve the efficiency of a loud speaker, it is necessary to match the impedance of the relatively heavy vibrating system to that of the air. A horn accomplishes just this—it is an acoustic transformer which converts high pressures and small velocities at the throat to low pressures and large velocities at the mouth.

It was originally believed that a horn merely confined the sound within a limited angle with a corresponding increase in intensity in this region. Conical horns were widely used in the past to increase tne radiation from loud speakers. More recently it has been found that the real function of the horn is to

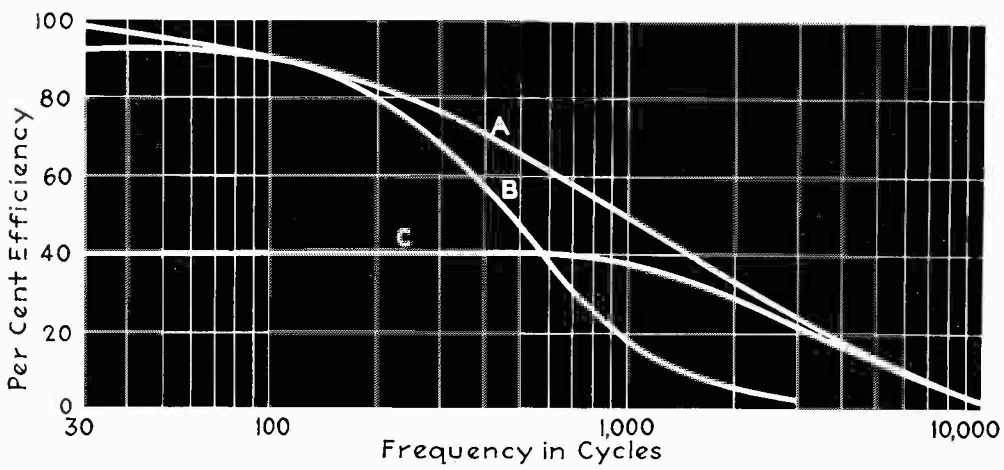


Fig. 7. Efficiency of horn type speaker driven by diaphragm having an effective mass of 2.5 grams and an area of 120 sq.cms.

A. Maximum efficiency obtainable if horn impedance were matched to the cone impedance at each point in the range

B. Efficiency characteristic with a throat area such that the horn impedance matches the diaphragm impedance at 100 cycles

C. Efficiency characteristic with smaller throat horn in which horn impedance matches diaphragm impedance at 7,000 cycles increase the load on the vibrating system.[3] For a given throat area, the impedance of the horn depends on its shape, and it has been found than the exponential rate of flare gives more uniform loading than any other type. Figure 5 shows the throat resistance of three horns of the same throat area and different shapes which indicate why the exponential type is to be preferred.

The exponential horn is defined by the relation

$$A = A_o e^{mx} \qquad (9)$$

where:
A = area in sq.cms. at any distance x cms. along the axis,
A_o = area in sq.cms. at the throat ($x = O$),
m = flaring constant.

The flaring constant determines the cut-off frequency of the horn which is given by

$$f_o = 2730\, m \text{ cycles per second} \qquad (10)$$

To design an exponential horn to give a certain cut-off frequency, the value of m can be computed from equation (10). This constant is then placed in equation (9) from which the shape of the horn can be determined. It must be emphasized that the low-frequency cut-off of the horn is determined by the *rate of flare* and not by its length. It is quite possible to have a short exponential horn producing lower frequencies than a much longer exponential horn, provided the initial area at the throat of the first horn is sufficiently larger than the throat of the long horn.

The choice of throat size (A_o in eq. 9) is determined by the area of the diaphragm which drives the horn, the larger diaphragm requiring the larger throat. It is a matter of choice whether a small diaphragm with a small throat should be used or a large diaphragm with a large throat. For a fixed rate of flare and mouth opening, the smaller the throat the longer the horn must be. Sometimes space requirements prevent the use of a straight long horn, so it becomes preferable to use a short, large throat horn with the larger diaphragm.

The longer horn may be folded to save space, but this procedure usually entails a loss in high-frequency output. A loss occurs when the difference in path length between the shortest and longest distance around a bend approaches a half wavelength. This means that for high-frequency reproduction only the small sections of the horn can be bent without causing trouble.

The mouth opening of a horn must be determined by the wavelength of the lowest frequency to be transmitted through it. For a small mouth opening, if a sound of very low frequency is to be radiated, a reflection will occur at the mouth as the wave emerges, due to the abrupt change in impedance between the small mouth and the atmosphere. These reflections give rise to peaks and dips in the resistance characteristic of the horn which, in turn, produces a ragged response. It has been found that to prevent serious reflections in a horn, the diameter of the mouth should be at least as much as ¼ wavelength of the lowest frequency to be radiated.

To get some quantitative idea of

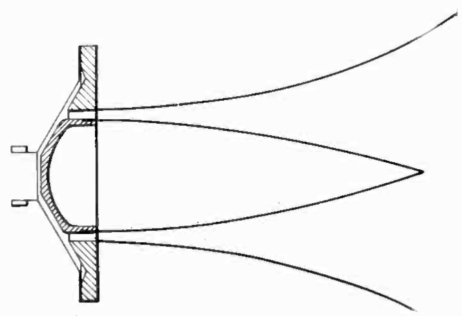


Fig. 8. Annular throat construction to reduce interference at the high frequencies

the factors involved in the choice of diaphragm and throat area in a horn loud speaker, consider the equivalent circuit in Fig. 6. The constants shown in the figure have the following meaning:

C_{A1} = acoustic capacitance of the volume behind the cone $= \dfrac{V_1}{1.45} 10^{-6}$.
V_1 = volume of air in enclosure in cc.
C_{A2} = acoustic capacitance of the volume of air between the horn throat and cone $= \dfrac{V_2}{1.45} 10^{-6}$.
V_2 = volume of air between throat and cone in cc.
M = inertance of the vibrating system = m_o / A_c^2
m_o = effective mass of voice coil and cone in grams.
A_c = effective area of the cone in sq.cms.
r_A = acoustic resistance of the horn = $42/A_h$
A_h = area of horn at throat in sq.cms.

After substituting numerical values, the equivalent circuit in Fig. 6 can be easily solved to show, quantitatively, the performance of the loud speaker at various frequencies. The voltage to be assumed acting in the circuit is equal to $Bli/10A_c$. Using this value of equivalent voltage, the power computed flowing through r_A is equal to the acoustic power being radiated by the speaker.

Looking more critically at the equivalent circuit, it can be seen that the value of C_{A_1} should be made high enough so that its impedance is low compared with the value of ωM at the lowest frequency which must be reproduced. If, however, a peak is desired in the output at some part of the frequency range, C_{A_1} may be adjusted so that it resonates with ωM at the desired frequency. When this is done the output will drop off at frequencies below resonance.

The effect of C_{A_2} is to cause a loss in output at frequencies above which the reactance becomes comparable in magnitude to the throat resistance. To preserve good high-frequency response, therefore, the throat volume should be kept very small so that its reactance at the highest frequency of reproduction is high compared with the throat resistance.

Assuming that C_{A_1} and C_{A_2} are so designed that they do not influence the performance of the speaker in its working range, it can be seen from Fig. 6 that maximum radiation efficiency at a given frequency will occur when $\omega M = r_A$. Thus, the optimum size of horn throat for a given cone follows directly.

The maximum efficiency of a horn loud speaker at any frequency is equal to

$$\text{Max. Eff.} = \frac{K}{2\,\omega m_o r_e + K} \times 100\% \qquad (11)$$

where
$K = (Bl)^2 \times 10^{-9}$,
r_e = electrical resistance of voice coil in ohms.

This equation shows that it is inherently a simple matter to get very high efficiencies at low frequencies where ω is small. At the higher frequencies, where ωm_o becomes a large factor, the efficiency decreases rapidly. Of course, it is evident that increasing the flux density, B, produces a large gain in efficiency, especially at the higher frequencies. Increasing l, the length of conductor in the voice coil, does not cause much gain in efficiency, because m_o and r_e are simultaneously increased.

Figure 7 shows that the smaller throat improves the high-frequency performance and at the same time reduces the low-frequency efficiency. Thus, it appears preferable to use more than one horn speaker to cover a wide frequency band; large throat horns for the low-frequency region; and small throat horns for the high-frequency range. Another reason for avoiding small throats on horns having a low cut-off frequency is to reduce distortion due to overloading the atmosphere at the throat, especially for large acoustic outputs, as will be discussed later. At high frequencies, if the cone is relatively large compared with the wavelength, a loss in output will occur due to interference of the sound coming into the horn throat from different parts of the cone in the construction of Fig. 6. (See Fig. 8.)

For high-frequency reproduction, a relatively small diaphragm is required for better performance. The small diaphragm is undesirable at low frequencies for two reasons: (1) because it will necessitate a very long horn, and (2) because the amplitude of the diaphragm for a given power output becomes too large.

Horns Needed for High Output

To design a loud speaker for high acoustic output, it is almost imperative to use a horn. The inherently low efficiency of the flat baffle type, if it were used, would impose at least two very serious objections. In the first place, the source of audio supply for the flat baffle speaker would have to be many times greater than would be required for the horn type for the same acoustic output. Secondly, and most important, the rate of heat generated in the voice coil would obviously be many times greater in the low efficiency speaker for a given output requirement.

The rate of heat generation in the voice coil is one of the most important problems which confronts the designer of a high-power speaker. For a given size of voice coil, the temperature rise is directly proportional to the power input, and a dangerous limit is reached at relatively low ratings for conventional speakers. For example, a horn loud speaker operating at 25 per cent efficiency showed a measured temperature rise of 90° C. when 20 watts of electrical power was supplied to the mechanism. The voice coil consisted of 1 gram of enamelled aluminum wire wound on a $1\frac{9}{16}''$ diameter paper collar. An air gap clearance of 0.018″ existed between each side of the voice coil and the pole pieces.

The temperature rise in this speaker for 20 watts input (5 watts output) is too high for the paper collar construction employed and the speaker would undoubtedly fail if operated continuously under this condition.

Virtue of Redesign

The above speaker was re-designed to be 50 per cent efficient and at the same time the air gap clearance on each side of the voice coil was reduced to 0.013″. Twenty watts input (10 watts output) on the speaker now cause only 40° C. temperature rise. For the same temperature rise of 90° C. as occurred in the original speaker this new unit required a power input of 45 watts, which produced 22½ watts of acoustic power output—an increase in rating of 4½ times over the first speaker. Two factors have contributed to permit this increased rating: the higher efficiency, with its resulting reduction in voice coil dissipation, and the smaller air gap clearance which permitted easier transfer of heat from the voice coil to the field structure.

In the design of loud speakers to give several hundred acoustic watts output, besides making the efficiency as high as possible and the air gap clearance a minimum, the outer surface of the voice coil conductor must be increased with increasing rating. Also, the paper form must be avoided in building up the voice coil to eliminate the possibility of its burning up at the temperatures which are encountered. Special temperature resisting cements must also be employed in the voice coil assembly.

Another problem is that of the large mechanical forces which come into play at the high outputs. These forces may be of the order of 50 lb. so that extra precaution must be taken in fastening the voice coil to the cone. The usual procedure is to both sew and cement the voice coil (conveniently made of flat ribbon instead of wire) to the cone.

Another serious problem which arises in horn type speakers is the distortion due to overloading of the atmosphere at the throat. If the sound pressures at the throat become a reasonable fraction of atmospheric pressure, the velocity of propagation of the wave crests will be increased due to the higher density of the air, and the velocity of the troughs will decrease due to the lower density. Thus the wave front becomes steep with the corresponding introduction of harmonics.

M. Y. Rocard in *Comptes Rendus* (January 16, 1933) works out the theoretical value of the amplitude of the second harmonic which will be generated in the throat of a horn, and he finds that the amount of power which can be generated per sq.cm. of throat area for a given amount of second harmonic distortion is directly proportional to the square of the cut-off frequency and inversely proportional to the square of the fundamental frequency generated in the horn.

From the information of Rocard, this equation can be deduced:

$$R = \frac{\sqrt{W}}{40.5}\left(\frac{f_1}{f_c}\right) \times 100\% \qquad (12)$$

where

R = per cent second harmonic generated in the output,

W = acoustic watts output per sq.cm. of throat area,

f_1 = frequency of the signal impressed on speaker,

f_c = cut-off frequency of the horn.

Assume that a horn with a throat area of 100 sq.cms. and a cut-off frequency at 80 cycles is generating 10 watts of acoustic power at a frequency of 4,000 cycles. A solution of eq. (12) for this specific case indicates a second harmonic component in the output equal to 39 per cent of the fundamental. Although the exactness of this theoretical result must be subjected to experimental verification, it indicates most strikingly the terrific distortion that will be introduced if large amounts of high-frequency power are to be reproduced through a horn having a low-frequency cut off. In the above problem, if two speakers were used to cover the frequency range instead of one, the second harmonic at 4,000 cycles would be 5½ per cent.

[1]Rayleigh, Theory of Sound, Macmillan, Vol. II, pp. 278 and 302.

[2]Olson and Massa, Applied Acoustics, Blakiston, Philadelphia, p. 165.

[3]Webster. A. G.: *Proc.* Nat. Acad. Sci., 1919.

Stewart, G. W.: *Phys. Rev.*, 1920, p. 313

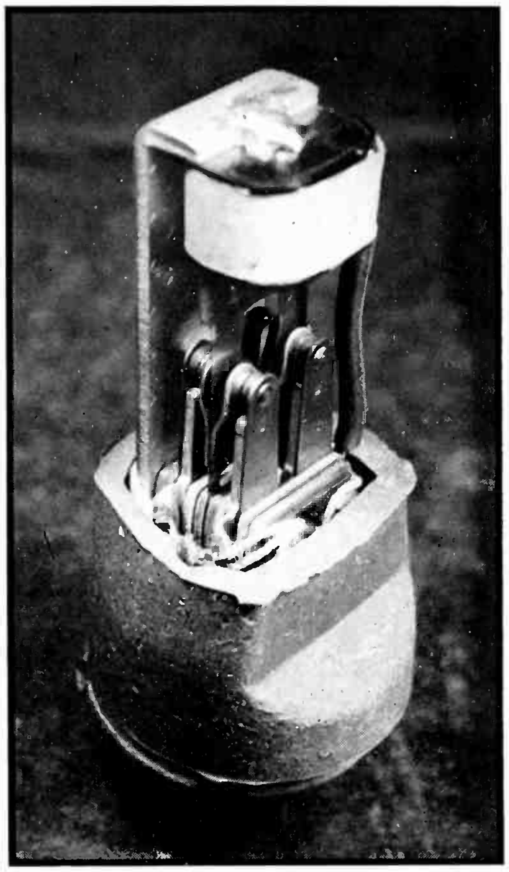
Slepian and Hanna: Amer. Inst. Elec. Eng., 1924, p. 384.

Ballantine, S.: *Jour.* Franklin Institute, 1927, p. 85.

Assembly of parts selected as to dimensions (Mallory)

◆

New Mallory 8-contact vibrator



VIBRATORS

Power supply from batteries by vibrators made auto radio possible. There are wider vibrator uses, too. Circuits, materials, construction

ALTHOUGH some battery operated radio receivers were installed in automobiles by a few hardy pioneers as early as 1922 or 1923, nothing much happened to put life into this huge potential market until the bugaboo of carrying around heavy B batteries was laid away by the development of the vibrator as a power converting device. Motor generators or similar rotating machines were engineered for this purpose but they could not compete with the vibrator once its early problems were overcome.

In 1931 a nationally known manufacturer placed an interrupter in one of the storage battery terminals, producing pulsating d.c. which was stepped up by a transformer and fed to a gaseous rectifier and filter system to produce d.c., more or less free from noise. From that date the progress in vibrator design was rapid; in fact the growth of the vibrator from its early crudity to the refined apparatus now sold to the number of a million a year is remarkable, considering the problems, and the short time in which this progress has been made.

In the following review of the present vibrator situation, the Editors have been aided by Dr. Marvin Blackburn, I. M. Slater, T.M. Rosser of P. R. Mallory, Billie Thomas of Radiart, William Garstang of Electronic Laboratories, R. A. O'Reilly of Oak Manufacturing, C. T. Wallis of Delco Appliance Corporation.

Vibrator Problems

Now one might think it to be a simple problem to make a vibrator, following the automobile spark coil art, but no manufacturer of these efficient devices would say so nor would any be so rash as to say that all problems had been licked. Early models were half wave types in which the actuating coil, the contact points, the battery and the filter were all in series. The points had an annoying habit of sticking together with the result that the vibrator or the set wiring or both were burned up. Furthermore the unit, being polarized, had to be connected up in the proper direction to prevent ruining the vibrator or the electrolytic condensers. It was most difficult to filter free from hum or noise. It delivered only about 35 ma. at 180 volts, not enough to provide sufficient loud speaker signal to be heard above car, wind and tire noise.

What was needed was a unit that would deliver an output easier to filter, and one that would start on 4 volts and not burn up on 8.5 or even 9 volts delivered by the car generator at high speeds.

There are now full-wave vibrators with shunt actuating coils which provide an output rectified by various types of tubes specially designed for auto-radio purpose, and there are vibrators which not only interrupt the battery voltage but rectify it too. They are known as synchronous types, and their operation is made possible by a double set of contacts, one to interrupt, the other to open and close the circuits so that current flows in a single direction.

Present tendencies seem to be about 50-50 for the synchronous and the tube-rectifier types. Some set manufacturers prefer one, some the

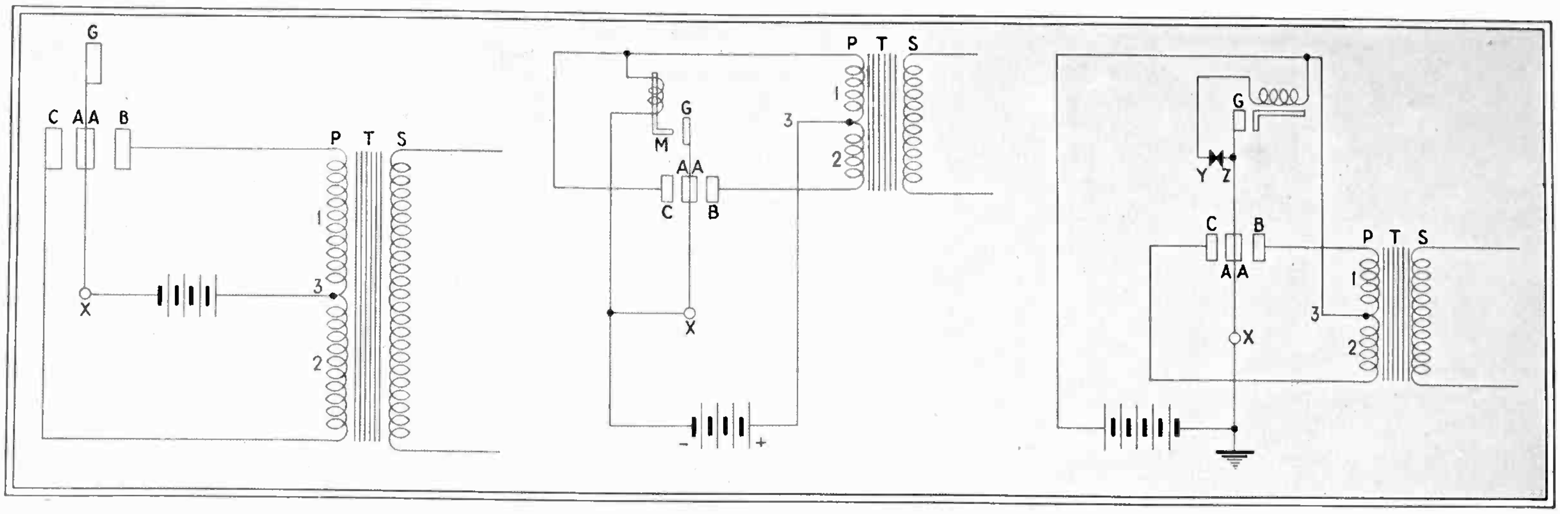


Fig. 1—Series type vibrator circuit. Figs. 2 and 3—Shunt circuits (Data from Radiart Service Course)

other. The synchronous types do not require filament power for the tube, but they seem to be more difficult to filter, and in the opinion of some engineers have more things that can go wrong with them.

One most interesting development of the vibrator business has been the production of a line of 32 and 110 volt units. The latter act as inverters of considerable power (150-300 watts) replacing rotary converters because of their lower price, their greater portability, and their greater efficiency. This is a most important development, since there are many uses for a source of a.c. secured from a source of d.c.

Vibrators brought with them other problems: Transformers to step up the strange wave forms produced by the interrupters; contacts to handle the peak currents of 8 or more amperes; reeds and side rods that would not crystallize or burn up; methods of dissipating the heat generated; methods of getting rid of r-f interfering noise known as "hash"; mechanical vibration which communicates itself to other radio or automobile parts; audio hum; and of course higher and higher power and greater efficiency demanded by set and automobile manufacturers.

Vibrator Circuits

The simplest type of vibrator circuit is the series half-wave connection in which the contacts merely open and close the battery-to-transformer circuit. The full-wave series type is but slightly more complex. A center tap is made to the transformer primary. The battery is between this center tap and the reed which vibrates between two contacts connected to the two ends of the transformer primary. The driving coil, nowadays, is always in a shunt circuit as shown in Fig. 2 or 3. In Fig. 2 when the magnet pulls the reed to make contact between A and C the magnet is shorted so that the reed moves back and through its neutral position to close contacts A and B. Figure 3 is a shunt vibrator with a series driving coil. An extra point Y carried by another spring arm is in contact with Z in the neutral position. Current flows through the coil, the contacts YZ to ground and pulls the reed or armature toward B which breaks the current through the coil and permits the natural spring of the reed to pull the contacts back toward YZ.

Series types have the inherent limitation of low resistance coils drawing large currents from the battery in case the vibrator sticks. If the coil has high resistance, it must dissipate much heat and of course the voltage drop across it is prohibitive. For this reason manufacturers are now using the shunt coil type whether for synchronous rectification or for tube rectification.

In the synchronous full-wave vibrator shown in Fig. 3 the center tap is maintained positive, and the negative terminal does not vary in sign. For farm sets where maximum battery life before recharging is desirable the synchronous type is preferred. It is said that this type is harder to filter than the tube type, and that the saving on the tube may be made up in the more costly filter. High voltage buffer condensers are required, the purpose of these condensers being to limit the voltage rise upon breaking the circuit by the vibrator contacts. This inductive voltage may be as high as 5000 if the normal transformer output is of the order of 300 volts. Much depends upon the proper design of the transformer, and the buffer condenser. Recent practice is to reduce the size of the condenser from 0.002 to perhaps 0.0003 mfd. The condenser controls the point in the a-c cycle at which the contacts open.

There are other variables in design and circuit. The frequency at which the reed vibrates may be from as low as 90-odd cycles to as high as 150. The higher frequency units seem to be harder to filter both for hum (a.f.) and hash. The metals used for reed, for side rod, for contacts have been studied with considerable assiduity; the portion of the contact cycle in which they are actually in contact—known as the "time efficiency"—plays its share in the performance; life depends upon many factors; should the contacts come together lightly, or under much pressure, should they wipe, what should be the acoustic insulating material, and how much. All these matters are variables which distinguish one manufacturer's product from another's.

On the Market

In practice the vibrator is assembled piecemeal on jigs out of parts selected for dimensions. In older models the spacing between the various elements is adjusted and fixed by operators as one of the final operations. In more recent types tolerances in making the individual parts are so small that in final assembly

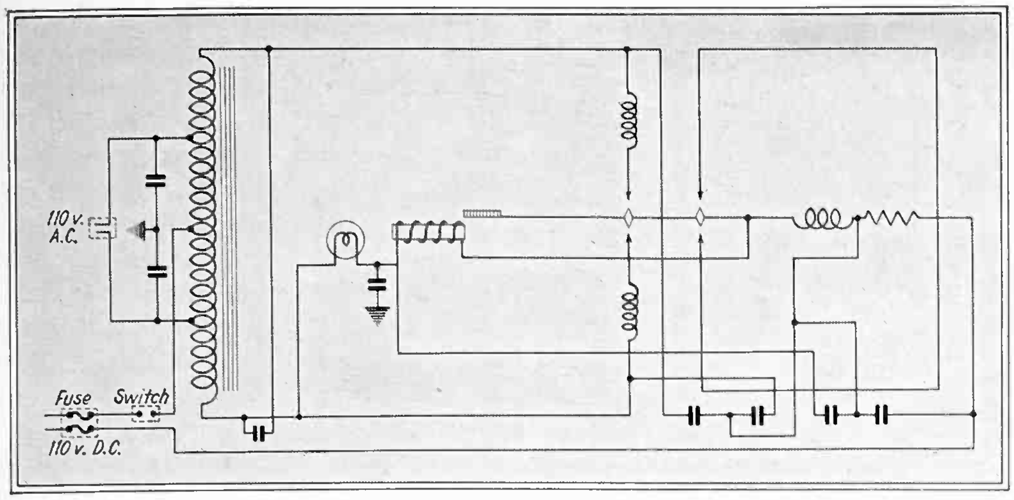


Fig. 4—Circuit of Electronic Laboratories d.c.-a.c. converter

very little or no adjustment is necessary.

In the Oak non-synchronous vibrator shown the single driving contact is in the middle, framed by the reed assembly. The reed is made of Swedish spring steel and carries the driving contact on an extended portion of itself, with the contact release plates on one side. The reed power contacts are mounted on separate plates. These are fastened to the spring at the point where minimum loading of the reed is consistent with proper contact pressure and contact gap spacing.

The sponge rubber base is non-tarnishing and supports, cushions and insulates the base. A sponge rubber cap in the top of the can permits limited free motion. The rubber seal in the base has considerable acoustical importance. It is held fast by a special plastic base and snap ring. The reed driving coil is bifilar wound; one winding of chromoxide wire driving the reed; the other winding is short circulated and absorbs hash and reduces arcing at the contacts.

On the outside center of the frame is the driving contact. Only a single adjustment is necessary. Since Oak designs vibrators for manufacturers' individual requirements this final adjustment can be made and the unit sealed before shipment.

The synchronous type has four contacts instead of two. Another type has a split reed so that the rectifier circuit and interrupter circuits may be isolated. Thus the voltage drop in the B circuit may be used for grid bias. The Oak high power type will carry 22½ watts at 6 volts. It is non-synchronous, has contacts 0.218″ in diameter, special alloy fins dissipate the heat.

Oak uses Oakalite rod tungsten for power contacts of the ground disc type measuring 0.175″ to 0.218″ in diameter with a grain count of 50,000 per square millimeter. The side contacts are resiliently mounted to provide proper percentage of closure time, and a quick break as the contacts open at practically the maximum velocity position of the reed. The driving contacts are made of special palladium silver alloy.

Some novel advancements in mechanical design have been made in a new vibrator soon to be announced by P. R. Mallory and shown to the Editors on a recent visit to the Indianapolis plant. This is a small unit with the most marked difference with older types of having parallel contacts, mounted on independent supporting springs for the non-synchronous type. The frame is constructed of one piece of metal which also forms the core for the driver coil. With this design it is possible to hold the dimensions to much closer tolerances than with any previous design. These close dimensions permit the use of a driver coil of a radically different type. Previously coils of this type were made of three or more pieces. The internal heat of the vibrator was responsible for the expansion of the wire, which would cause the bobbin ends to interfere with the vibration of the reed, or it was necessary to make the core longer so expansion would have no effect. In the new Mallory vibrator a moulded bakelite coil bobbin is used. In the construction of this bobbin it is necessary to use a special "mix" of bakelite powder. After weeks of experimental work, this special "mix" was selected so that bobbins having only the greatest possible strength and a minimum wall thickness could be obtained. This "mix" was also selected because of its ability to resist "wire expansion."

There are many novel features of the stack assembly. In the past it has been impossible to build stack assemblies, in production quantities, without manual adjustment of the contact point spacings, either by bending the side springs or by using screw adjustments. Spring bending is not satisfactory since all metals have a tendency to "reset" after being bent. The "reset" of the spring is accelerated by the heat of the vibrator and in a short time the contact point spacings will change sufficiently to cause the vibrator to be slightly out of adjustment. This causes rapid wear of the contact points. In the new Mallory vibrator the parts are held to extremely close production tolerances.

By using carefully selected stock

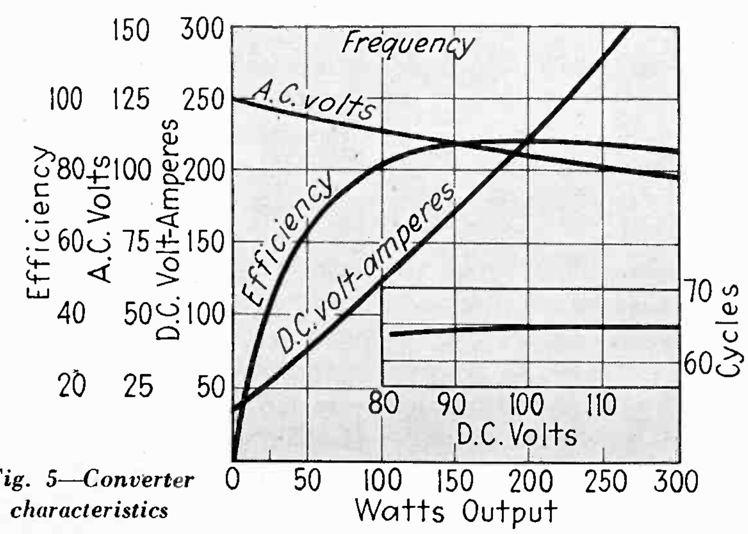
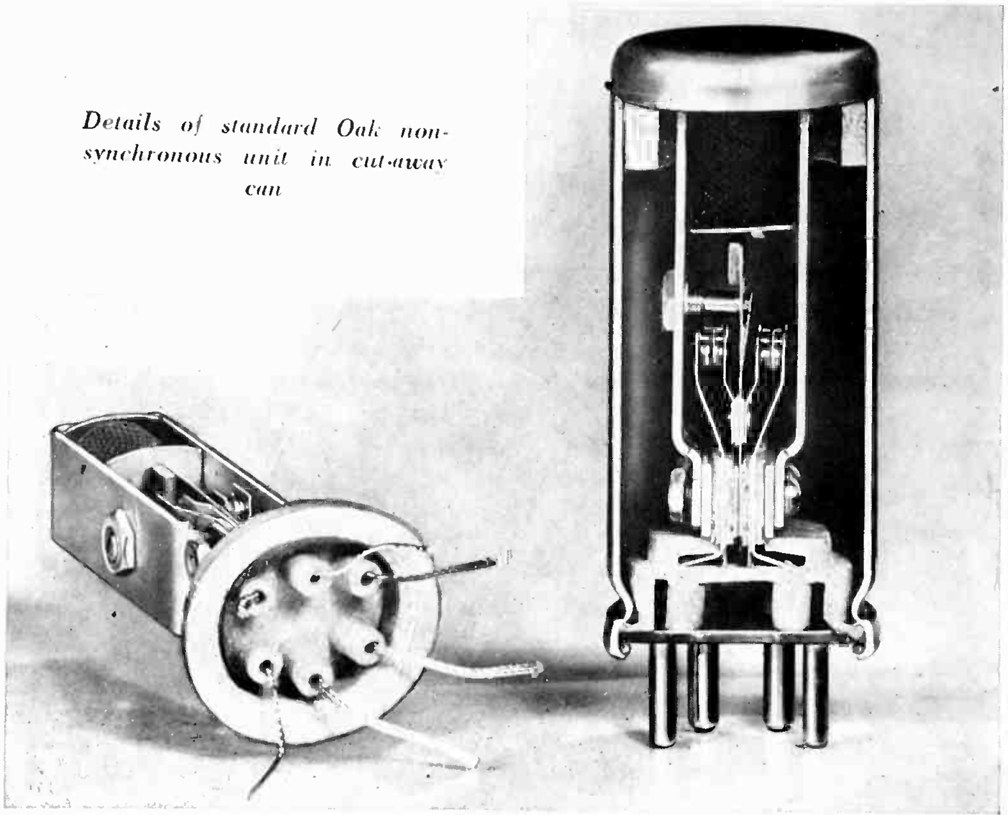


Fig. 5—Converter characteristics

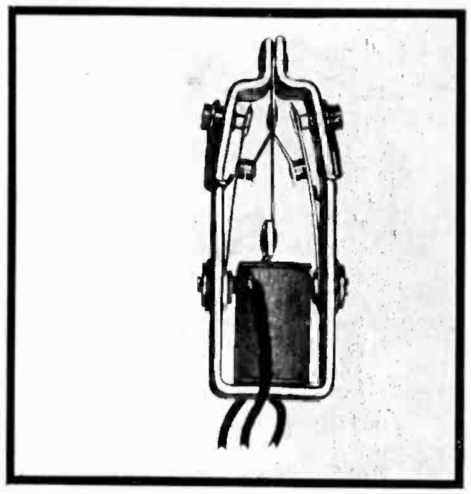


Details of standard Oak non-synchronous unit in cut-away can

condensers are mounted in slots on the frame of the rectifying type, and near the rectifier in the simpler type.

Wiping action at the contacts is secured on the synchronous type by inclining the contacts. Screws adjust the spacing by varying the stationary contact springs. A resilient spring system aids in obtaining the proper saturation time. Stationary contact springs on the simpler unit are mounted cantilever fashion on the frame.

Vibrators are placed in metal cans with rubber lining proportioned to obtain the greatest sound absorption in the available space. Delco vibrators work at about 95 cycles. Long contact life is secured by large reed amplitude with high rate of separation to prevent any tendency to arc.



Delco unit with inclined contacts

for reeds and auxiliary springs with careful heat-treatment to relieve manufacturing stresses, and combining parts made from this material with stock parts accurately ground to tolerances of ten-thousandths of an inch in thickness, the assemblies go together with such accuracy that no bending or deformation of vital moving springs is required to secure correct spacings of the contacts and thus good operation of the units. This means that all units should perform the same and that a defect in the vibrator because of a failure of some adjustment to "stay put" cannot occur. This insures longer and more uniform life.

The design of the new Mallory vibrator incorporates higher contact pressures than those in any of the small type vibrators. The use of tungsten in its many forms as contact material is predicated entirely on the use of contact pressures of sufficient magnitude to break through the tungsten oxide formed during operation.

Higher contact pressures make the vibrator more noisy mechanically. The higher mechanical noise required a sound insulating liner in the can that would prevent the mechanical noise from escaping and also reduce the vibration to an acceptable value. The sound insulator, or "sock" of the new vibrator suppresses the mechanical noise and vibration to an acceptable level and still conducts enough heat to permit the vibrator to operate at a reasonable temperature.

The housing of the vibrator is made of extruded zinc and is $1\frac{1}{2}''$ x 3 3/16", not including the connection prongs. The flat end of the can is designed so as to have a heavy tapered end for the elimination of the diaphragm action.

The photograph shows that there are 8 contacts in the new unit. The object is to so distribute the load between the contacts that longer life would result.

The time efficiency, or time the contacts are closed against the total time of oscillation, has been greatly improved. The improved time efficiency gives an improved wave form which permits the circuit to be changed to improve life of the vibrator, and to give greater efficiency. Only minor changes in the circuit are required.

Greater uniformity, less space, decreased mechanical noise and vibration, greater efficiency, greater ease of replacement (Mallory has a large replacement business) and improved appearance are the virtues of this new construction from the standpoint of the user according to Mallory engineers.

Delco vibrators use heavy U-shaped frames with the coil at the closed end. Four pairs of contacts are used on the synchronous type, two on the other types. Timing

Careful choice of materials used in vibrators is necessary for long life. Tungsten seems to be universally used for contacts. The decision of Mallory engineers to use parallel contacts is dictated by the following reasoning: tungsten as a contact material has the characteristics of having no mechanical wear but having electrical wear or erosion. This erosion is caused by flaking off of tungsten oxide caused by sparking at the contact points and the flaking must take place for tungsten to be exposed to make contact at the next closure at that point. The rate of forming of this oxide is increased as the current handled by the contact increases, but is not directly proportional, being somewhat of a 3/2 power proportion. Since only a point connection is made on a single contact at any one closure, no advantage is gained when handling high currents by the use of large diameter contact points other than to provide a larger amount of tungsten to be eroded. By furnishing two springs in parallel, the design can be correct and still furnish two possible points for connection—one at each contact, since the contacts are independently sprung. This not only provides a possibility of reducing the current density in the contacts, but also furnishes a much greater conducting area in the springs and stops for carrying the current and heat away from the contacts.

The reed and outer spring materials in the new Mallory vibrator are of high grade chrome-vanadium steel, different types of this metal being used in the reed and contact springs. Bakelite spacers of new material designed for non-flowing characteristics are used. These spacers are ground flat and parallel to a tenth of 0.0001 inch. It is interesting to note that 15 separate grinding operations are necessary in this new vibrator; that horizontal double disc grinders are used for this purpose; that Carl Zeiss Opto-tests in conjunction with Johannsen gages are used for sorting the flat pieces and that shadowgraphs and optical comparators with magnifications of from 45 to 1 to as high as 125 to 1 are used in the more intricate pieces and assemblies.

After studying many alloys and metals for semi-stationary reeds that must carry considerable current and which must preserve their original shape and position, Electronic Laboratories has come to the use of Monel metal. This organization found a considerable increase in vibrator life and freedom from rejects from the field after going to the use of this metal. (Readers interested in greater detail of this point should see *Time* December 9, 1935, advertisement of the International Nickel Company.) Monel is now used by this company exclusively for the side rods. The vibrating reeds are made of Swedish spring steel.

Even the acoustic insulating materials are chosen with care, and some of the companies making vibrators have developed patented methods of preventing noise from getting out.

Power Vibrators

Of more general application than the 6-volt units made expressly for automobile or farm radio sets, are the 32 volt and the 110 volt units, especially those of Electronic Laboratories which are really efficient sources of 110 volts a.c. secured from 110 volts (or 32) d.c.

In these vibrators the big problem is to get rid of the heat. The reed must be rigid, must carry the current, and yet must always start to vibrate when the input circuit is closed. Electronic Laboratories use a patented arrangement of a series coil resonated to the vibrating frequency of the reed, an external resistance to prevent too great heat loss, and a lamp whose resistance is at first low and then increases as the current through it increases. In this manner an additional starting torque is supplied to a stiff reed to make certain the the vibrator starts. Characteristics of the 110 d.c. to 110 volt a.c. are given here. (See U. S. Patent 2,020,681.)

Accessory Apparatus

Vibrators demand transformers, condensers, filters. This year's vibrators seem to be better designed than formerly, particularly from the standpoint of efficiency and wave form. Now that oscillographs are being used to a greater extent in vibrator research, the causes of hash and hum are being discovered. The benefit of improved time efficiency is being learned.

Vibrator manufacturers now want to know from the set manufacturer the specifications (or a sample) of the transformer to be used; the power required at given input voltage (or current and voltage) a circuit of the power pack, the primary circuit, with regard to condensers, resistors, etc.

In general the transformer is to be of low flux density and low leakage reactance. These factors are met by a comparatively large cross section of iron and few primary turns. The buffer condenser must be such as to correct the power factor during the transition period between one set of contacts and the other to prevent an inductive spark at the instant of make and break.

Metal-Clad Tube for Colleges

[*Continued from page 18*]

each type of connection. The tube can also be easily modified to include three anodes and three associated grids, so that it can be operated either as a rectifier or as an inverter. Studies can be made of the design of grids and their relative position as related to the anodes and cathode. Experiments can also be performed involving voltage regulation by means of grid control, high-speed electronic circuit breaker protection using the grids to interrupt power, inversion of reactor energy, speed control of d-c motors, dynamic braking of d-c machines, frequency changing, static coupling of networks with power flow in either direction, and d-c transmission of power. The tube is of sufficient capacity to be used with apparatus already available in laboratories for carrying out all of these experiments.

Very recently steel-tank power tubes have been demonstrated for speed-control and dynamic braking of d-c motor drives, and since they possess many advantages in comparison to motor generator sets for this application, it is likely that they will soon be used for supplying power to and controlling the operation of paper and textile machinery, printing presses, conveyors, fans, pumps, blowers, compressors, mine hoists, rolling mills, etc. Among the most important advantages of power tube control for variable-speed drives are higher overall efficiency; steadier operation at full speed and particularly at slow speeds; lower maintenance cost; quieter operation; insensibility to disturbances on the a-c system; immunity to dust, metallic vapor, fumes and moisture; possibility of direct connection to any system voltage; and ability to control independently several motors connected to a single multiple-anode power tube.

R-F Power Measurements

By measuring peak grid-driving voltage by a direct reading rectifier type r-f voltmeter, or by the use of a rectifier-type dummy load, transmitter power may be measured within 10 per cent

By G. F. LAMPKIN
Bradenton, Florida

NEXT to field strength, power is perhaps one of the hardest quantities to measure in radio transmitting practice. This is unfortunate, since, next to field strength, power is about the most significant quantity. Very often material in the literature gives details of transmitter circuits or adjustment procedure, but does not enable the reader to judge as to the actual efficacy of the arrangements since accurate data as to power are not included. Such statements as "it would burn out a 100-watt bulb," or "it would maintain a 3-inch arc," etc., really mean very little. With a simple and fairly accurate means of power measurement at hand, the informative interchange of transitter knowledge should be greatly encouraged.

Of the methods of radio-frequency power determination, the calculation of I^2R from measured values of current and r-f resistance is probably most used. It is laborious to the extent that resistance measurement at radio-frequencies is laborious, and particularly so when the effective resistance is encountered as a variable. Other methods, which utilize an r-f wattmeter, calorimeter, or temperature rise, are too roundabout for any general application. The use of a light-bulb as a dummy load is not desirable, because the lamp resistance changes over a ten to one range, from hot to cold. The resulting variation in load can completely obscure other effects which might be under investigation.

In transmitter engineering, grid-driving power is of particular interest, both because it represents the output power of the preceding stage, and because it relates to the efficiency of the driven stage. The fundamental grid circuit of an r-f amplifier is depicted in Fig. 1, and below are shown typical curves of grid driving voltage, grid current, and grid bias voltage. Especially should be noted the fact that grid current flows only when the driving voltage is higher than the bias voltage—*i.e.*, on the peak of the voltage wave. If we multiply together instantaneous values of the input voltage and of the current which it produces, a curve results which represents the total input power. The average power can be figured in the usual way, by dividing the total area under the curve by the length of the base line (one cycle).

However, since the current flows only at the peak of the driving wave, the driving voltage can in practice be considered constant during this interval, and the averaging process can be considered in conjunction with the current only. The average of the grid-current wave over one cycle is the d-c value. The average power input to the grid is then simply the d-c grid current times the peak driving volts. This first was pointed out in the literature by Thomas.[1]

It will be apparent that the smaller the operating angle of the grid current, the more accurate will be the power values obtained. For instance, if the grid current flows for 40° out of the 360°-cycle, a sinusoidal grid driving voltage will always be between 94 per cent and 100 per cent of its peak during that time. It will also be apparent that greater accuracy will result if the actual peak value of the voltage wave is measured, rather than to calculate it from the r.m.s. value. The latter procedure assumes a sinusoidal wave, which assumption is not justified under the usual interstage tank-circuit conditions. Power readings obtained by the product of peak voltage and grid current will tend to be high, but seldom will be in error more than 5 per cent to 10 per cent.

Probably the simplest way to measure the peak driving voltage is

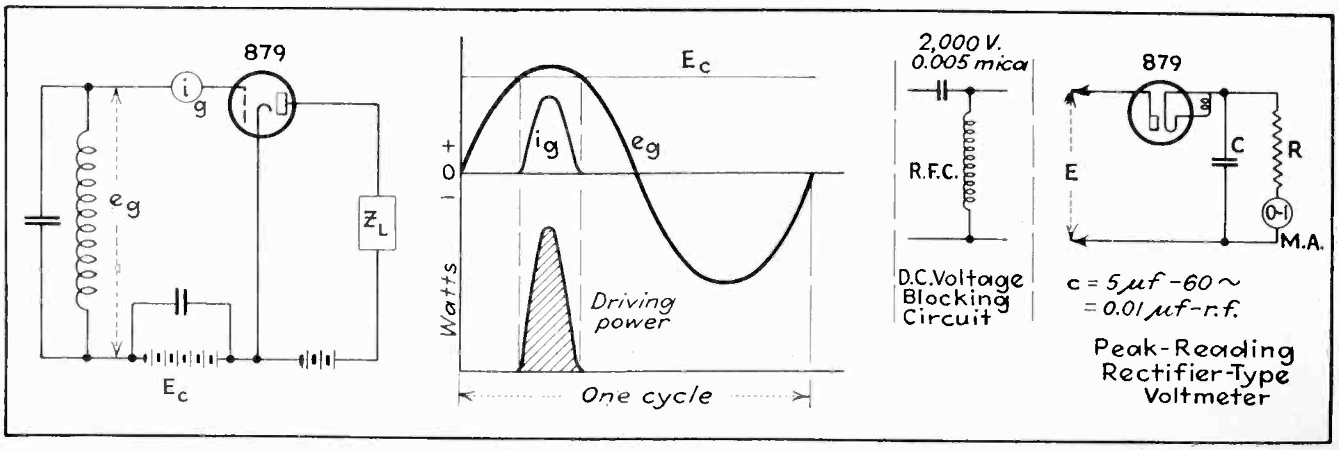


Fig. 1—Fundamentals of r-f power amplifier and details of rectifier voltmeter

to use a peak-reading rectifier-type voltmeter, set up with an RCA 879 type rectifier tube in the circuit of Fig. 1. By connecting sufficient capacity at C, so that the discharge is negligible between cycles, the meter will read and can be calibrated directly in peak alternating volts input. The calibration can conveniently be performed at 60 cycles, using at least 5 μf capacity at C. To calibrate, measure the 60-cycle voltage at E, which will be r.m.s. value on any ordinary a-c voltmeter. Multiply this figure by 1.414 and plot the resulting peak voltage against the corresponding reading on the 0-1 d-c milliammeter. Taking one or two readings at the upper end should be sufficient to plot the calibration line, which will be straight for all practical purposes. Changing the resistance, R, will change the scale of the meter; a value of 182,000 ohms gave a full-scale peak voltage of 250, 415,000 ohms gave 500 volts peak, and 880,000 ohms 1000 volts peak.

Although the electrode capacity across the 879 is only 1.0 $\mu\mu$f, its impedance is relatively important at radio frequencies and must be taken into account. The effect is to bypass the rectifier, or decrease the rectification efficiency, as the frequency increases. As a result the voltage readings obtained on any given frequency must be multiplied by a factor as shown in Fig. 2A, for that frequency. The factor will be substantially the same for different values of multiplier resistance, R.

The 879 can be used as a direct-reading rectifier-type r-f voltmeter, by using an IRC Type F-1 metallized resistor as the multiplier with a small equalizing capacity in parallel, and rearranging the circuit. It will read voltage directly over a wide range of radio frequencies without requiring correction for frequency error. The circuit and construction of the multiplier-equalizer are shown in Fig. 3, and the frequency error in Fig. 2. The equalizer capacity was set for zero error at 3500 kc., and had a measured value of 3.37 micromicrofarads. The full-scale range was 165 volts r.m.s. for values shown on the circuit diagram.

This voltmeter arrangement is mentioned because it was developed during the investigation of r-f power measurement, and because it has advantages in other types of r-f work. For grid driving voltage it is not well suited, because it reads average rather than peak voltage and so is subject to waveform error. The equalizer capacity across the multiplier resistor must be adjusted empirically at radio frequency, and a calibration setup more complicated than for 60 cycles is required.

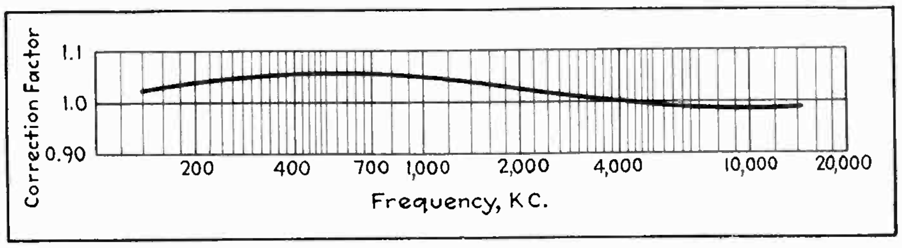


Fig. 2—Direct reading equalized r-f voltmeter

In the application of the peak-reading voltmeter to push-pull input circuits, the total grid driving power is equal to the peak voltage, measured from one grid to cathode, times the total grid current. If the input is unbalanced the average of the peak voltage on each grid might be taken, for better accuracy. The voltmeter circuit itself as shown in Fig. 3 can be connected only between points which have no d-c bias or plate voltage difference. Usually it will be entirely satisfactory to clip across the tank inductance from grid to cathode points. If the cathode point, although at ground for radio frequency, is hot with high plate voltage the filament transformer on the 879 and the meter and the multiplier must be insulated from ground for the high voltage. If such is impossible or inconvenient the voltmeter may be provided with a blocking condenser and r-f choke to keep out the direct potential. Because the 879 voltmeter has an input capacity of only 1 micromicrofarad it will cause a minimum of disturbance to any r-f circuit across which it is connected.

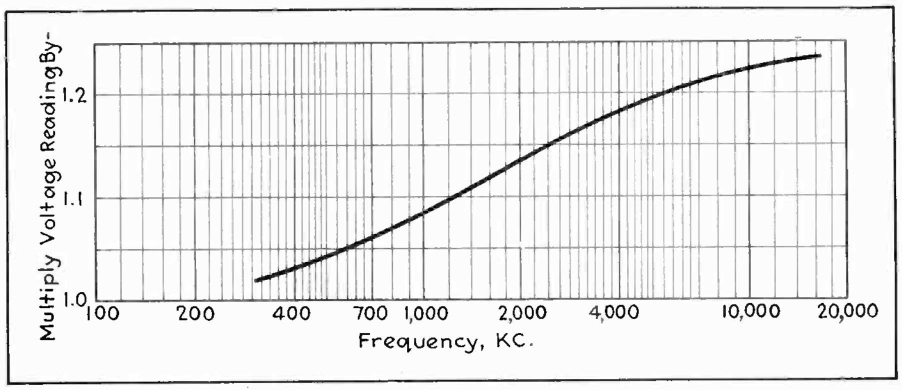


Fig. 2A—Calibration correction factor for peak-reading voltmeter

The above material on grid-driving power suggests that a further step can be made, towards a dummy load for r-f power, based on the same principle. Instead of driving the output of a transmitter into an antenna, it may be fed into a rectifier-resistance combination and there measured with comparative ease. Going a step further, for a given type rectifier, the tube loss can be plotted as a function of the direct current, and the dummy load can be utilized also as a wattmeter. The peak-reading

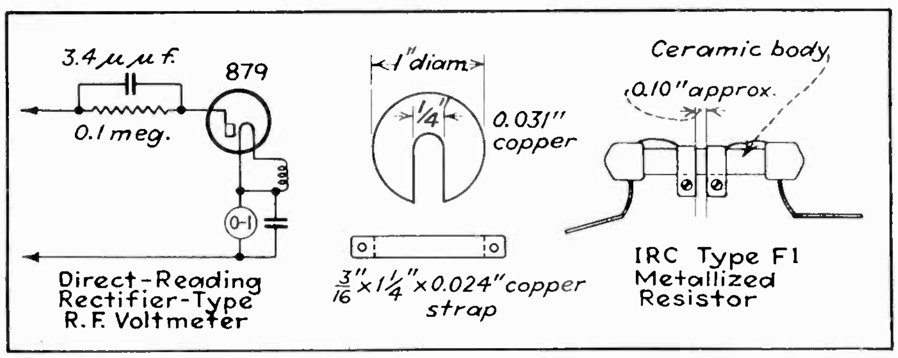


Fig. 3—R-f voltmeter and multiplier-equalizer details

[Please turn to page 64]

Tests to Insure Tube Quality

Highly intangible factors determine the uniformity and life of expensive power tubes. A written pedigree based on exhaustive tests and showing reason for final replacement enables quality to be maintained and improved.

By HARRY F. DART
Electronic Tube Engineer
Westinghouse Lamp Company

BECAUSE of the nature of the work they must perform, the wide variety of materials in their make-up, and the many unique processing treatments to which they are subjected, electronic tubes are a great deal more complex, both in function and design, than many other manufactured products. For this reason rigid quality control is at once more necessary and more difficult to maintain than with most other fabricated products and hence elaborate and expensive inspection equipment is essential.

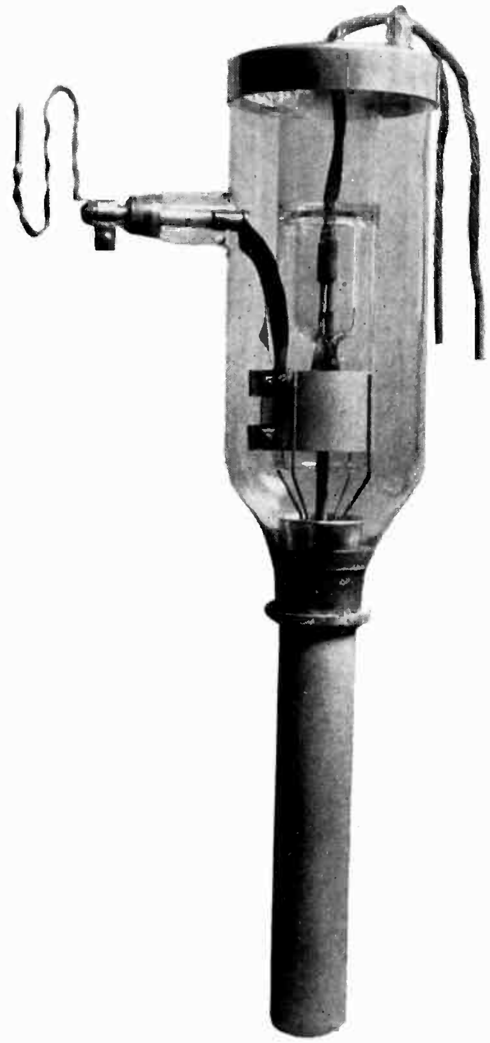
In controlling the quality of any product, it is, of course, necessary to start at the very beginning and maintain adequate supervision over all raw materials. Such supervision involves more than a mere inspection of the characteristics of the material, because the source of the ore—the country in which it is mined—frequently has considerable bearing on the value of such material for filaments and other parts of electronic tubes. Therefore, best quality will be achieved when the component materials are secured and pre-treated by the organization which manufactures the tubes.

To assure uniformity, the material is inspected for appearance and other visual conformity with the established standards; for mechanical requirements so that it can be used without breakage or other trouble in processing; and for specific resistance and any other essential electrical characteristics which may affect its ultimate use. Finally, a chemical analysis ascertains the exact nature of the material as well as the presence of any foreign matter. Necessary in maintaining uniformity, these inspections are made at periodic intervals during the run of a batch of material as well as at the time a new lot is received.

Filament structure, checked by this cross-section microphotograph, reveals crystal formation of greatest importance in determining tube life (magnified 170 diameters)

Filaments Inspected in Cross Section

The life of an electronic tube depends chiefly upon the filament, which must be made according to rigid requirements to assure uniformly long life in a tube. The manufacture of a satisfactory filament starts with the careful selection of the ore with especial regard to its chemical composition. The ore is purified and processed with suitable control at each stage of its conversion into a shape which can be used readily. After the tungsten is drawn into wire of the desired size, various lots are processed and subsequently inspected by means of microphotographs of polished cross-sections, as shown in the illustration. A wire lot, which meets the specifications, is set aside and ear-marked for this particular service.



Rigid control of materials and processing is necessary to insure tubes costing as much as $500, such as this WL-207

Special treatment determines the proper crystal size and structure in filament wire. Known as a flashing schedule, it involves a gradual increase in filament temperature which eventually approaches the melting point of tungsten. Electric current is passed through the filament wire, while it is mounted in an atmosphere of inert gas, thus forming the filament into the proper shape and promoting the desired crystal growth. Since accurate control of this process is essential, microphotographs are taken periodically to insure that the desired crystal structure has been formed.

It is interesting to note that one form and size of crystal structure is essential for filaments used in one type of tube, while other crystal structures will give different characteristics required in other types of tubes. For example, thoriated tungsten filaments should have a fairly large number of crystals of such shape that the active thorium can boil to the surface of the wire and replenish the supply which is gradually consumed during the tube's operation.

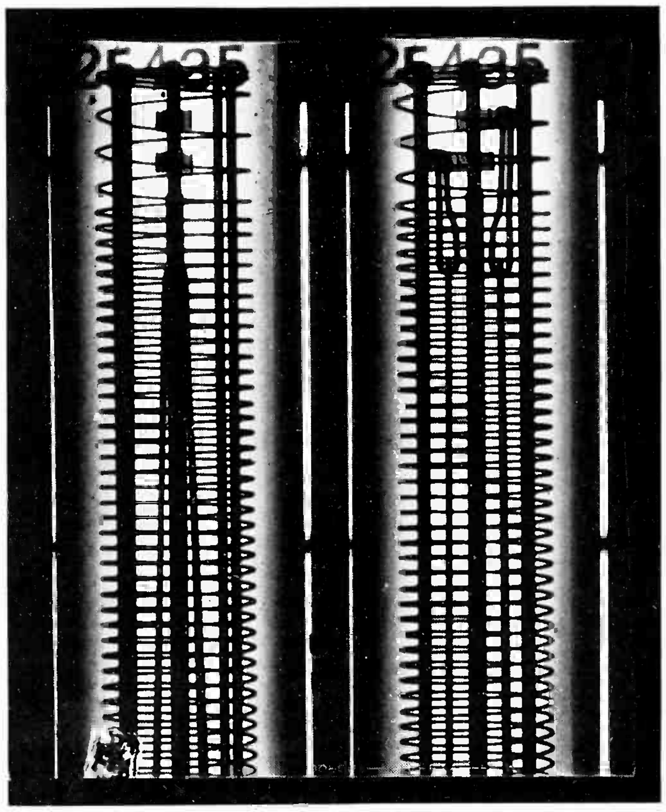
Tube parts must be treated to remove impurities which exist in the original ore. For instance, all metals, as well as all glasses, inherently contain many times their volume of gases. Pre-treatment, to clean the surface and partially degasify the parts, may consist of heating them to high temperatures in an atmosphere of hydrogen. More complete degasing is obtained by subsequent vacuum furnace or induction treatment. Parts are then carefully wrapped in paper, both to indicate that treatment has been completed and to prevent subsequent contamination. To make the most of pretreatment, parts are assembled and sealed-in as promptly as possible. Should it be necessary to hold them overnight, or for longer periods, they are stored in a vacuum container. Operators must wear gloves to prevent even the small amount of oil on the skin from adhering to tube parts after they have been cleaned.

Care in Glass Working

Glass working is necessarily performed at high temperatures. The glass must be allowed to cool slowly and uniformly so that annealing will obliterate strains set up during shaping and which would otherwise cause cracks. Polarized light is utilized to detect any specimens not entirely free from strains. Such specimens are rejected. Since gas is present in all metals and glasses to varying degrees, quality is obtained only by exhausting individual tubes to a uniformly high degree of vacuum. To degas the elements within the tube, they must be heated to a temperature much higher than that at which they actually operate. Most of the gas present in the glass envelope is removed by heating the tube to a maximum temperature consistent with safety and without injury to any of the parts of the tube. Also, the exhaust must be conducted as expeditiously as possible in order to maintain clean bulk appearance. By means of Pirani and ionization gauges, the vacuum condition can be ascertained at any time and the presence of leaks detected.

Grid Aligned With Filament

To obtain the uniform characteristics of electronic tubes, as for example, the water cooled type, it is necessary that the filament and grid be properly aligned with respect to each other and to the surrounding copper anode. Anodes are X-rayed after the assembly has been sealed-in to reveal the exact position of the inner structure and to facilitate alignment measurements.



Filament and grid alignment in copper anode water-cooled tubes is checked by X-ray, as shown in these two pictures taken at right angles. A further picture is taken after exhaust to check against failure due to the high heat of bombardment

Use of Production Tickets

Absolute control is exercised in operating tests where characteristic readings give the final indication as to the quality and uniformity of tubes. If any tube does not meet the narrow specification limits, it is rejected and immediately called to the attention of the factory engineer for prompt diagnosis of the difficulty so that it can be corrected before other tubes meet the same fate.

The importance of maintaining detailed records in the control of tube quality cannot be over-estimated. For that reason individual tickets must accompany each tube through all manufacturing procedure, as shown on the front cover. It supplies a complete history of the tube for permanent filing. The factory engineer examines the test readings and complete tube records before the tube is packed and must approve its release. Data thus accumulated are invaluable in the establishment of higher standards of quality, and in tracing or correlating field experience.

In conclusion then, it is seen that, unlike many other manufactured products, the quality of an electronic tube depends upon certain intangibles, such as occluded gases, material purities, and factory precision and cleanliness, factors which cannot be directly measured in the finished article itself. For this reason these and other factors which determine final quality call for careful scrutiny and control at each successive stage of processing as an unceasing guard against invisible defects which would render the tube less reliable.

Antennas For Air Navigation

The table opposite has been compiled for pilots who use aircraft radio direction finders of the homing type. For the radio engineer, also, it is of distinct interest for its relation to the broadcast interference problem

By DONALD G. FINK
Associate Editor, Electronics

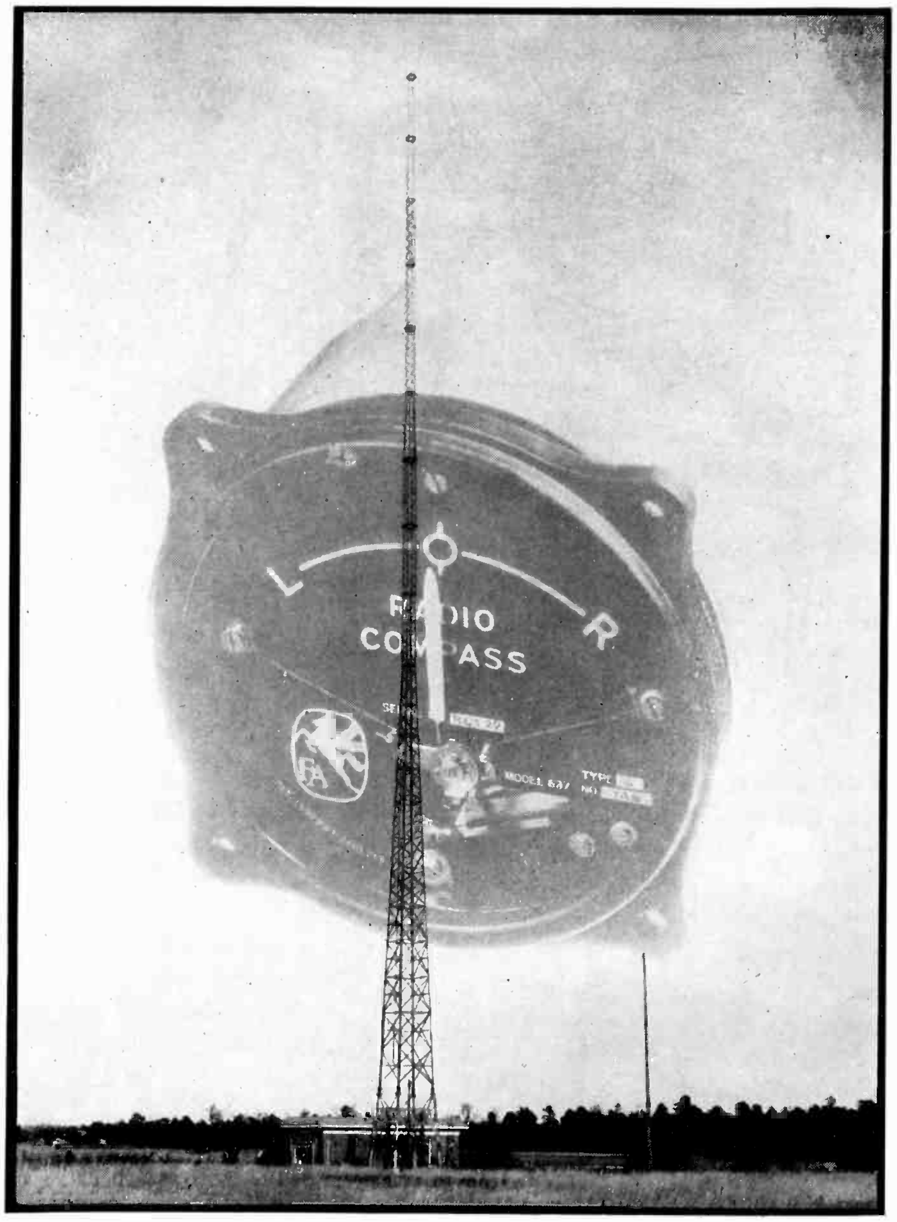
ONE problem which besets the aircraft pilot who uses radio broadcast stations for direction finding purposes is the lack of information on the exact geographical location of the antennas from which the signals are radiated. This information is available in the Berne List; it is corrected by mimeographed statements from the FCC, but it is not in a form easily used by the pilot, nor does the information reveal other important characteristics of the station, particularly its susceptibility to interference from stations on the same and adjacent channels.

In the preparation of "Aircraft Direction Finders" (*Electronics*, October, 1935, page 7) the need for such information in suitable form for pilots' use was stressed by all the men interviewed, including engineers engaged in the design, production and operation of the equipment.

The pilot wants this information: the locations (more or less exact) of stations toward which he can aim his direction finder; the degree of reliability with which he can identify the station by its frequency or call-letters; and finally, the hours of operation, to guard against a sign-off which would leave him without a signal to follow. He must have some means of selecting stations free from interference since a mixture of two signals, even though differing widely in strength, will so distort the effective wave-front (on which his loop is trained) that grave errors of direction may, and usually do, result. Simultaneous and synchronized operation of stations must therefore be guarded against. Shared-time operation is also dangerous, for in many instances the pilot has no time to wait for station call-letter announcements, but must depend on the frequency of a station for its identification. Shared-channel stations do not permit such identification unless the exact schedule of hours taken by each station in the group is known, and all changes in this schedule taken into account.

All of the 620 broadcast stations are not equally suitable for direction finding purposes. The problem arises of choosing those stations which are most suitable, making clear that most of the other stations may be used under proper conditions if care is taken to avoid errors. In determining the relative suitability of stations, the last court of appeals is a comprehensive field-strength and interference survey taken in aircraft by means of direction finding equipment. Such knowledge will eventu-

[*Continued on page 66*]



Successful use of the "homing" radio compass depends on exact knowledge of antenna locations

BROADCAST STATIONS SUITABLE FOR AERONAUTICAL DIRECTION FINDING

LOCATION BY STATES	CALL	FREQ. IN KC.	POWER IN KW.	INTER-FERENCE	ANTENNA LOCATION LONGI-TUDE ° ′ ″	ANTENNA LOCATION LATI-TUDE ° ′ ″	APPROXIMATE LOCALITY OF ANTENNA
ARKANSAS							
Hot Springs	KTHS	1060	10	42*	93 02 00	34 28 45	3 mi. s. Hot Springs. 2 mi. e. Airport.
CALIFORNIA							
Belmont (San Francisco)	KPO	680	50	18*	122 14 00	37 32 30	
Buena Park (Los Angeles)	KFI	640	50	30*	118 00 50	33 52 47	20 mi. s.e. Los Angeles
Los Angeles	KNX	1050	50	27	118 28 16	34 07 25	3 mi. s.w. of Van Nuys, California
Oakland (San Francisco)	KGO	790	7.5	32	122 12 20	37 45 54	
COLORADO							
Denver	KOA	830	50	25	104 46 50	39 44 21	12 mi. e. State Capitol Bldg., Denver
CONNECTICUT							
Avon (Hartford)	WTIC	1040	50	32	72 48 20	41 46 35	8 mi. w. Travelers Insurance Tower
FLORIDA							
Gainesville	WRUF	830	5	35	82 20 30	29 38 45	1.5 mi. s.w. Court House Square
GEORGIA							
Atlanta	WSB	740	50	20*	84 15 20	33 50 45	10.4 mi. n.e. center Atlanta
ILLINOIS							
Addison (Chicago)	WMAQ	670	50	C	88 04 23	41 56 01	4 mi. n. Glen Ellyn
Downer's Grove (Chicago)	WLS-WENR	870	50	C	88 00 30	41 44 35	3.5 mi. s. Downer's Grove
Elgin (Chicago)	WGN	720	50	C	88 12 53	42 00 46	
Glenview (Chicago)	WBBM	770	50	S	87 49 46	42 05 42	18.3 mi. n.w. Chicago Loop
Mooseheart (Chicago)	WJJD	1130	20	39	87 37 35	41 53 00	35 mi. w. Chicago Loop
York Township (Chicago)	WCFL	970	1.5	40	87 59 14	41 49 09	
IOWA							
Ames	WOI	640	5(D)	46	93 38 30	42 01 30	2 mi. w. Ames
Des Moines	WHO	1000	50	12	93 20 48	41 39 08	14.9 mi. n.e. Des Moines
KANSAS							
Milford (Abilene)	KFBI	1050	5	47	96 42 49	39 09 40	10.5 mi. n.w. Junction City, Kan.
KENTUCKY							
Jeffersontown (Louisville)	WHAS	820	50	12	85 34 40	38 12 10	12 mi. e.s.e. center Louisville
MARYLAND							
Pikesville (Baltimore)	WBAL	1060	10(D)	42	76 44 08	39 21 40	9.5 mi. n.w. center Baltimore
	WBAL	760	10	S	(Synchronized with WJZ, Bound Brook, N. J. at night)		
MASSACHUSETTS							
E. Springfield	WBZA	990	1	S	72 33 00	42 08 00	3.1 mi. n.n.e. center Springfield
Millis (Boston)	WBZ	990	50	S	71 20 05	42 11 03	18 mi. s.w. center Boston
Saugus (Boston)	WHDH	830	1	56	70 59 40	42 26 15	
MICHIGAN							
Detroit	WJR	750	50	2	83 13 00	42 10 07	16 mi. s. Detroit
MINNESOTA							
Anoka (Minneapolis)	WCCO	810	50	25	93 19 02	45 10 01	2 mi. s.e. Anoka, Minn.
MISSOURI							
Kansas City	WHB	860	1(D)	57	94 33 49	39 07 54	0.25 mi. n. Missouri River
St. Louis	KMOX	1090	50	C	90 20 42	38 27 36	13.7 mi. from City Hall, St. Louis
St. Joseph	KFEQ	680	2.5(D)	44	94 52 10	39 46 32	1.0 mi. n.w. St. Joseph, near Mo. River
NEBRASKA							
Lincoln	KFAB	770	10	S	96 41 48	40 49 41	
NEW JERSEY							
Bound Brook (New York)	WJZ	760	50(D)	25	74 30 50	40 33 20	1.5 mi. s.e. Bound Brook
	WJZ	760	50	(Synchronized with WBAL, Baltimore at night)			
Cartaret (Newark)	WOR	710	50	11	74 14 54	40 35 46	1.5 mi. w. Cartaret on Rahway River
Wayne (New York)	WABC	860	50	23*	74 17 12	40 55 30	6.1 mi. n. w. Paterson, N. J.
NEW MEXICO							
Albuquerque	KOB	1180	10	37	106 37 32	35 11 32	8 mi. n. Albuquerque
NEW YORK							
Bellmore (L. I.) (New York)	WEAF	660	50	20*	73 31 49	40 41 07	
New York City	WNYC	810	1(D)	59	74 03 35	40 42 22	Western end Brooklyn Bridge, N. Y. C.
Rochester	WHAM	1150	50	21	77 26 55	43 00 12	14 mi. s.e. Rochester. 2 mi. n. Victor, N. Y.
S. Schenectady	WGY	790	50	17	74 00 36	42 47 37	4 mi. w.s.w. Schenectady, N. Y.
NORTH CAROLINA							
Charlotte	WBT	1080	50	42	80 53 28	35 07 52	8 mi. s.s.e. Charlotte
OHIO							
Brecksville Vil. (Cleveland)	WTAM	1070	50	11	81 37 22	41 16 50	
Mason (Cincinnati)	WLW	700	500	C	84 19 30	39 21 05	22 mi. from Cincinnati
OREGON							
N. Portland	KEX	1180	5	45	122 41 15	45 36 22	5.5 mi. n. business dist. Portland near Columbia River
PENNSYLVANIA							
Newtown (Philadelphia)	WCAU	1170	50	27	75 24 50	39 58 30	12.8 mi. w. City Hall, Phila.
Saxonburg (Pittsburgh)	KDKA	980	50	C	79 49 00	40 43 53	23.5 mi. n.e. Pittsburgh
Whitemarsh Twnp. (Phila.)	KYW	1020	10	22	75 15 00	40 06 25	
SOUTH DAKOTA							
Sioux Falls	KSOO	1110	2.5	43	96 45 30	43 32 20	3 mi. w. Sioux Falls
TENNESSEE							
Franklin (Nashville)	WSM	650	50	C	86 47 32	35 59 50	
TEXAS							
Dallas	KRLD	1040	10	46	96 51 12	32 54 18	
Grapevine (Ft. Worth)	WBAP-WFAA	800	50	15*	97 01 35	32 55 04	11 mi. n.w. Love Field, Dallas
Selma (San Antonio)	WOAI	1190	50	25	98 18 33	29 34 45	
UTAH							
Saltair (Salt Lake City)	KSL	1130	50	25	112 06 03	40 46 30	
VIRGINIA							
Mechanicsville (Richmond)	WRVA	1110	5	37	77 22 43	37 36 10	5.5 mi. n.e. Richmond on edge Chicahominy Swamp
WASHINGTON							
Seattle	KJR	970	5	31	122 18 30	47 47 15	10 mi. n. Seattle

Notes: **Name of town** is government listing. The symbol **(D)** indicates daytime operation only; all other stations operate more or less continuously from 8:00 A.M. to 12:00 midnight, local time. **Interference:** the higher the interference rating, the more likely the station will be interfered with by other stations on same channel. *Stations having an interference rating higher than 40 should be used with caution.* ***** indicates no interference at night. **C** indicates no interference (clear channel). **S** indicates this station operates synchronously with another station; *signals from such stations should be used with extreme caution.* **Other abbreviations:** mi. = miles. n. = north. w. = west. s. = south. e. = east.

Self-opening Doors

In 1930, Mr. Raymond sold his company the idea of making phototube door openers. Now, 1936, the missionary period is over, the project is in the black. An excellent example of a company that took a single electronic application and made it successful

By **HORACE H. RAYMOND**
The Stanley Works
New Britain, Connecticut

SEVERAL descriptions of "Stanley Magic Doors" have been published during the past five years. The user walks between two posts, breaking a light beam which passes from one post to the other like a ghost thread. A photoelectric relay trips an air valve and the pneumatic operator swings the door open and holds it there until the person passes through.

The first public exhibition of the "Magic Door" was at the Grand Central Palace in 1930. The noble, humanitarian thought behind it was the emancipation of leg swinging, tray-balancing waiters. It was assumed that restaurant owners had generous and Christian feelings toward their waiters, and that as soon as they laid eyes on this electronic marvel they would reward the promoters with millions of orders.

The first order came from the owner of a shore restaurant who did not attend the Show. This may have been fortunate because the exhibition door had several vices — the clutch smoked, the gears chewed and the electric eye was partial to the larger type of hips owing to their superior light obstructing qualities.

On the opening day, after three weeks of successful testing the installation worked just three hours. The engineer spent the remaining nine hours perched on a shelf over the steam table in the kitchen, neatly tripping the faulty mechanism by hand each time a waitress approached, while the mystified public, having scanned the floor for hidden push buttons, had to turn to the evening paper for the true explanation which is faithfully copied, as follows, from a Connecticut newspaper—

> "Wilcox's Pier Restaurant at Savin Rock, West Haven, is the place to get shore dinners. And while you are there he will show you a door that is operated by a ray of light from the great star 'Arcturus'—it is a clever adoption of what is known as the electric eye. Guests at the Wilcox's Restaurant are at liberty to try one of these doors and see for themselves one of the greatest automatic mysteries of the electric age."

Now, at the beginning of 1936, it is evident that five years of pioneering have been successful. The equipment was originally designed for light weight, specially constructed doors in restaurants. The operating mechanism has been constantly improved so that operators are now made capable of opening and closing heavy bronze doors millions of times. This improvement in the equipment has opened new fields which were considered of less importance at the beginning. For instance, on store fronts; trying to find ways of giving more service, merchants are helping customers to get in and out of their stores with the "Magic Door." In the summertime there must be found some way to prevent the cooled air from going out—yet every merchant knows the handicap of a closed door. The photoelectric entrance not only solves the problem but actually attracts trade because of its novelty.

President Roosevelt's Georgia Warm Springs Foundation has a door to help "Polios" in and out of the building despite wheel chairs and crutches, while a hospital in Mexico uses one for the same purpose. New York's Pennsylvania Station provides a battery of doors for the traveling public which is not only a great convenience to the suitcase toter, but to the thousands of Long Island commuters with their shopping packages.

Doors have been installed on several entrances to bars in hotels, and have advantages which need no further explanation. Typical bars, hotel entrances, coffee shops and eating and dining places include:

- St. Anthony Hotel, San Antonio, Texas—4 entrance doors.
- H. P. Hood & Sons, Boston, Cafeteria—4 doors.
- Roosevelt Hotel, New Orleans, La.—4 doors.
- Hotel New Yorker—6 doors.
- Various private clubs in New York.

Typical store front entrance doors are:

- Scott Furriers,
  - Boston store—4 doors.
  - Hartford store—2 doors.
  - Providence store—2 doors.
  - Portland, Me., store—1 door.
- Glenn-Minnich Clothing Co., Roanoke, Va.—1 door.
- Franklin Hardware Co., Norwich, Conn.—1 door.
- Leed's Clothing Store, Baltimore, Md.—2 doors.

Industrial applications in warehouses, factories and in shipping rooms recently installed, include:

- Fiberloid Mfg. Co., Springfield, Mass.—1 door.
- Baker, Hamilton & Pacific Co., San Francisco—3 doors.
- Scott Paper Co., Chester, Pa.—4 doors.

An installation at the entrance to 40 Wall St., New York, is of interest because there are six doors in a row, two banks, one being automatic going

[*Continued on page 66*]

TUBES AT WORK

A PHOTOTUBE and a power amplifier are used to reproduce earthquake motions on a small scale for testing models of building structures. Power engineers develop a split-second trigger for a cathode-ray sweep circuit.

Tubes Aid Earthquake Study

VACUUM TUBES have recently been put to use in the study of earthquake motions by Arthur C. Ruge, a seismologist at the Massachusetts Institute of Technology. The tubes are used to control the motion of a "shaking table," a platform on which are mounted models of buildings, water towers (see illustration) or other similar structures. The table is then caused to move in a horizontal direction with abrupt and irregular motions similar to those produced by earthquakes. The effect of this motion upon the model structure can then be studied at will, and faults in its design corrected where necessary.

In the usual type of shaking table the motions imparted to the table are of more or less arbitrary character, but the new device used by Mr. Ruge makes it possible to reproduce motions which have occurred in actual earthquakes. A seismograph record taken during an actual earthquake is transferred to a shadowgraph, or "optical cam." The cam is in reality a polar plot of the earth's motion. This shadowgraph is then passed in front of a phototube in such a way that the amount of light entering the tube is controlled by the position of the cam. The output of the phototube is then led to amplifiers, analyzers and a final power amplifier which controls a magnetic valve. The force supplied by the final output stage available for moving the valve can be as great as 50 pounds. The valve controls a reservoir of oil under pressure, which by pressing against a piston causes the platform of the shaking table to move in accordance with the variations plotted on the optical cam.

The flexibility of this arrangement makes it possible to reproduce motions which could not be handled by the formerly used mechanical cams and levers, and the new device is particularly effective in irregular motions which do not repeat themselves.

Although 2,000 lb. of force are available to move the shaking table, only a small amount of this is actually used, just sufficient to make the table follow the motion of the shadow on the optical cam. By means of installing similar control devices for vertical motion and for horizontal motion at right angles to that now available, a completely general system is available for reproducing actual ground motion. The device promises to be of considerable value in the design of earthquake-resisting structures.

• • •

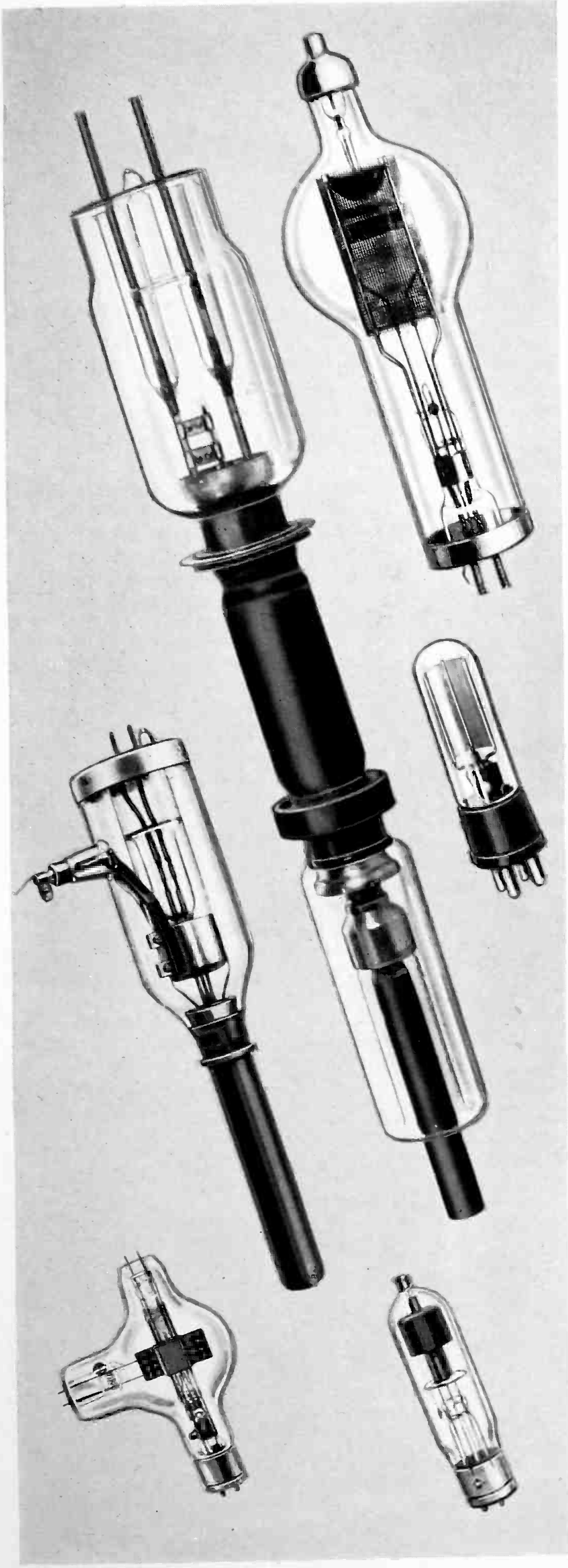
Electrical Device Guards Radium Workers

IN ADDITION to the regular precautions taken, the radium department of Westminster Hospital, London, is using a new electric "tell-tale" apparatus, which can be carried in the pocket. This will reveal, on examination at the end of the day, how much effective exposure the operator has received.

When going on duty the operator will take from a cabinet a small tube of elektron metal about 2 inches long, and in so doing will operate a simple "clocking in" apparatus which indicates the time at which he takes possession of his "tell-tale." At the end of the period for which he is on duty he will replace the tube and at the same time "clock out." Inside the tube is a thin rod of elektron, supported on amber buttons and charged to about 400 volts. The radium radiation which the operator encounters in the course of his work will cause this charge to leak off. The amount that does leak will determine the dose received.

It will thus be possible to keep from

The earthquake "shaking table." Actual earthquake records are plotted on the "optical cam" (white card, foreground) and caused to intercept light entering a photocell. The cell controls a power amplifier. This in turn controls a magnetic valve which admits oil under pressure to a piston connected to the table. The model water-tower is thus subjected to motions reproduced from actual seismic disturbances



✓RELIABLE
✓UNIFORM
✓RUGGED

● Every stage in the manufacture of Westinghouse Electronic Tubes is carefully controlled. Rigid specifications are set for each type and every tube is thoroughly tested and inspected to make certain that it meets these requirements. Thus you are assured that every Westinghouse Tube is of uniformly high quality and thoroughly dependable.

*For information on **Westinghouse** tubes write to—*

WESTINGHOUSE LAMP CO.
SPECIAL PRODUCTS SALES DEPT.
BLOOMFIELD, N. J.

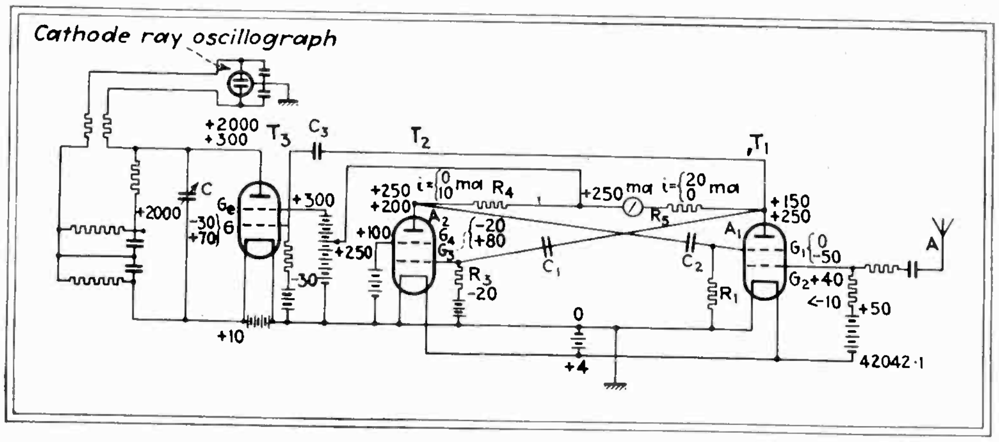
There is a Westinghouse Electronic Tube for every application.

Westinghouse *Electronic Tubes*

day to day a complete record of the incidental exposures received by each operator, and to ascertain whether or not these are within the safe limits.

• • •

Electronic Relay Trips Cathode Ray Sweep Circuit in 0.2 Microseconds



Electronic relay for tripping cathode-ray time sweep within 0.2 microseconds after the impulse is applied. The lower of the two figures given for plate and grid voltages is the value immediately after the impulse has appeared

USE OF THE cathode ray oscillograph for measuring transient voltage disturbances on high-tension transmission lines has recently been made by the Brown Boveri Company of Switzerland, as reported in the December 1935 issue of the *Brown Boveri Review.* While designed primarily for use by electric power transmission engineers, there is no doubt that the relay circuit will prove useful in many electronic applications of the cathode ray tube.

The circuit diagram of the device is shown in the illustration above. The tube marked T_3 is a conventional screen-grid discharge tube which causes the voltage across the condenser C to decrease linearly with time after the discharge has been initiated by the proper voltage on its grid G. For use in power transmission studies, the total time of sweep from beginning to end of the discharge is approximately 10 microseconds, but this period may be varied over wide limits depending upon the time constant of the capacity-resistance network between the discharge tube and the cathode ray tube. Tubes T_1 and T_2 constitute the electronic relay which applies the necessary tripping voltage to the grid of tube T_3.

At the extreme right of the diagram is an aerial A which is electrostatically coupled to the transmission line under consideration. When the transient voltage impulse (which may be a suddenly applied voltage, a short circuit or other fault), appears on the line, a voltage is electrostatically induced in the aerial A and is transferred through a resistance-capacity coupling to the grid G_2 of the tube T_1. It is assumed that the voltage thus applied is negative. If not, it may be inverted in phase by a phase-inverter tube. When the grid G_2 becomes negative, the plate current of the tube ceases and plate voltage is raised practically instantaneously from 150 to 250 volts. This increase in voltage is transferred through condenser C_1 to the grid G_3 of the tube T_2, making G_3 positive. At once the plate current of T_2 (approximately 10 milliamperes) flows, thus decreasing its plate voltage from 250 to 200 volts. This potential drop is transferred through the capacity C_2 back to T_1, with the result that a negative potential of approximately 50 volts is applied to the grid G_1. The original change in plate voltage of T_1 from 150 to 250 volts is transferred through C_3 to the control grid G of the discharge tube T_3, and at once the sweep period begins. The time necessary between the arrival of the impulse at the aerial and the beginning of the discharge is approximately 0.2 microseconds.

Should another impulse arrive at the aerial during the discharge period, the negative voltage applied to the grid G_1 will prevent its having any effect on the rest of the circuit, and as a result the sweep is allowed to continue without interruption to the end of its normal period. At the completion of the discharge it is necessary for the relay to reset itself ready for further tripping. This is accomplished by the following sequence of operation. The grid G_3, being positive, discharges the condenser C_1, which is also discharged through the resistance R_3. As the grid G_3 thus becomes negative, the plate current of tube T_2 drops, thus causing an increase in the plate voltage of the same tube which is transmitted through the condenser C_2 to the grid G_1. As soon as the grid G_1 reaches its normal potential (0 volts) the relay is again ready for the next impulse. This cycle of operation takes approximately one-third of a second.

The relay has been used in conjunction with a secondary time sweep circuit of a magnetic type and of much longer period, the purpose of the second sweep circuit being to keep the spot moving slowly across the screen of the tube to prevent its blackening the fluorescent surface or causing fogging of the photographic plate. The entire

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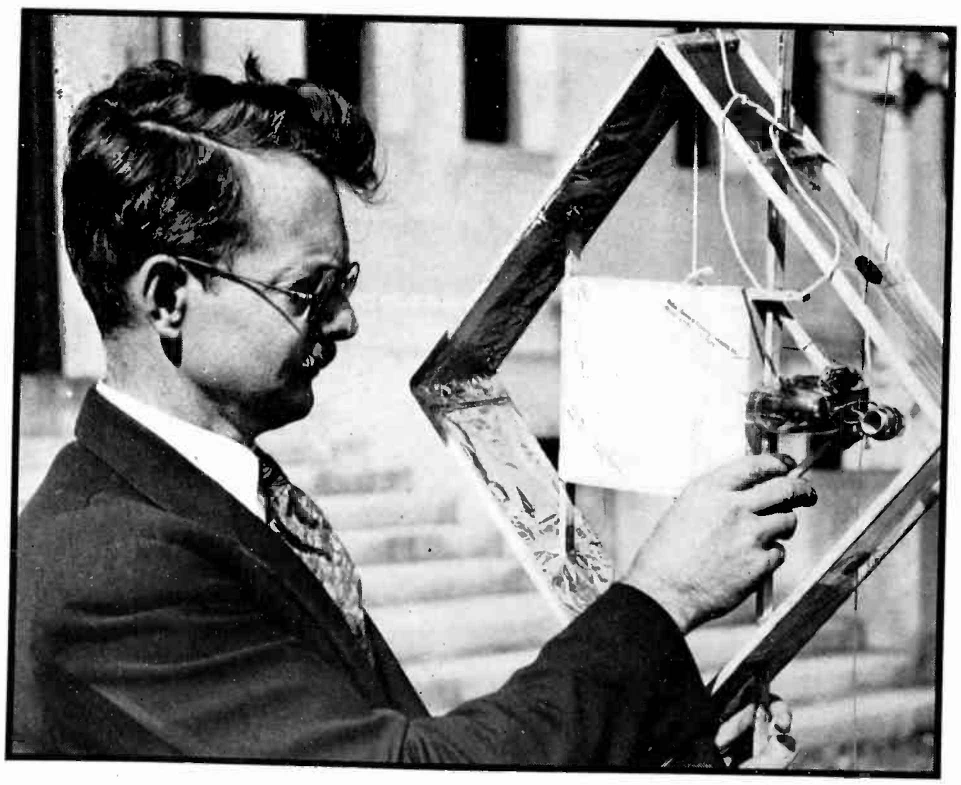
TWO-POUND TRANSMITTER FOR STRATOSPHERE



Dr. L. F. Curtis of the U. S. Bureau of Standards with a radio transmitter for attachment on meteorological balloons. A range of 80 miles at a height of 14 miles can be attained

ALWAYS READY TO OPERATE

NO ratio arms to find . . . . no standards to connect . . . . no oscillator to hook-up . . . . no power source to worry about. The Type 650-A Impedance Bridge is always ready to go. It is completely self-contained except for a pair of head telephones. It is an indispensable tool in every laboratory where measurements of resistance, capacitance, inductance, dissipation factor $\left(\frac{R}{X}\right)$ or energy factor $\left(\frac{X}{R}\right)$ have to be made frequently. It can be operated successfully with accurate results by anyone with a few minutes practice. It is direct reading to 2% over the major portion of its enormous range. The Type 650-A Impedance Bridge is priced at $175.00. Order direct from General Radio Company, 30 State Street, Cambridge, Massachusetts.

WRITE FOR CIRCULAR 70E FOR COMPLETE DETAILS

GENERAL RADIO

circuit is housed in a metal shield which prevents external fields from affecting its operation. The tubes used are of comparatively high power. The exact values of the resistances and capacitor used in the circuit are not given in the report, but may be readily computed by those familiar with elementary circuit theory.

• • •

Mercury Vapor Detector Uses Color Comparison

A NEW DEVICE for testing the presence of mercury vapor in the air has been perfected for the use of industries, such as those manufacturing of mercury filled rectifiers and control tubes, in which mercury vapor is often a menace to the health workers. The mercury detector makes use of a chemical compound, selenium sulphide, a yellowish chemical which turns brown when exposed to mercury vapor. In practice, the selenium compound is exposed to the air for a known length of time, after which its color is compared with a standard chart, which indicates directly the concentration of mercury vapor in the air during the exposure.

The detector is so constructed that in incandescent lamp causes a continuous flow of warm air past the selenium sulphide surface, a conical shield being used to direct the air from the bulb to the compound. Al-

G.E. mercury vapor detector and color comparison chart

though the color comparison is made by eye, it is possible to use a photoelectric comparator, thus providing completely automatic operation and making it possible to install the equipment in a remote location. As little as one part of mercury in one hundred million parts of air can be detected by means of this device, and since concentrations of vapor dangerous to human life are much higher than this, it is always possible to safeguard against dangerous conditions.

• • •

High Power Public Address System Used for Christmas Celebration

FOUR HUNDRED WATTS of audio power were used to radiate musical programs from the tower of the Lincoln National Bank and Trust Company in Fort Wayne, Indiana, during Christmas week. Programs consisted of phonograph records of Christmas carols and chimes, and other holiday music. By means of a telephone connection between the public address system and local radio station, WOWO, New Year celebrations in Paris, Bermuda, and San Francisco were distributed through the system. The equipment used consisted of some ten or twelve separate Class A power output stages, each consisting of a push-pull parallel arrangement of four type 250 tubes. Type 866 mercury rectifiers, and the necessary voltage amplifiers and drivers, were included with the power tubes in conventional panel rack mountings installed in the tower. A total of 19 stadium type electrodynamic speakers (12-inch cones) were mounted on the tower in separate plywood baffles of the directional type.

• • •

Intermittent Reception in Broadcasting Receivers

ACCORDING TO A survey made recently and published in the IRC Servicer, intermittent reception, which is the most difficult problem which the radio service man meets in receiver servicing, originates most often in the radio frequency or intermediate frequency circuits. By an analysis of service calls, the following list of causes of this trouble was compiled by A. C. Bradford: 40 per cent of the units causing intermittent reception are defective r-f or i-f plate or screen by-pass condensers; 35 per cent are defective resistors; 8 per cent coupling condensers, 6 per cent tubes; 4 per cent all types of transformers; 2 per cent defective speakers; 1 per cent mechanical imperfections and 4 per cent for all other causes.

This list, at first published for the benefit of service men, should likewise be highly illuminating to the designing engineer, who by careful attention to the first two or three items on the list may eliminate much of this sort of trouble at the source.

FROM POULSEN ARC TO COLUMBIA'S CYCLOTRON

Unloading a piece of the 130,000 pound magnet used in the arc transmitter at the Navy radio station at Annapolis until 1934, when it was replaced by vacuum tube equipment. The magnet has been given to Columbia University for use in the new 20,000,000-volt cyclotron (atomic bombarder) now under construction (see Electronics, November 1935, page 7)

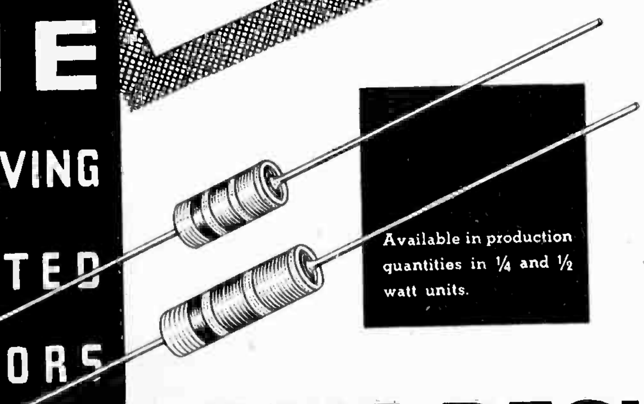
EXACTLY ONE YEAR AGO—

THIS ADVERTISEMENT ANNOUNCED AN ENTIRELY NEW TYPE OF RESISTOR

Use

ERIE

SPACE-SAVING INSULATED RESISTORS



Available in production quantities in ¼ and ½ watt units.

In February, 1935, this advertisement announced a revolutionary new resistor, unbelievably small in size for its rating and completely insulated by a ceramic shell.

On the basis of this improved design, claims of savings in set manufacturers' production costs, more efficient chassis designs and elimination of many wiring difficulties were made.

Now, after one year, experience has shown that Erie Insulated Resistors have fully lived up to these predictions. If you are not familiar with this outstanding development in carbon resistors, we will be glad to send you a generous supply of samples.

MANUFACTURERS OF CARBON RESISTORS AND SUPPRESSORS

ERIE RESISTOR CORPORATION

AUTOMATIC INJECTION MOLDERS OF THERMO-PLASTICS

TORONTO **ERIE, PENNSYLVANIA** LONDON

THE ELECTRON ART

DETAILS on two German television receivers of recent date show the present state of the art in Europe. A new graphical method of determining band-pass filter characteristics is reviewed.

New Developments in Television Receivers

[H. O. ROOSENSTEIN, BERLIN]. Sound and image are received on the common antenna (2 m. long) and amplified in an r.f. stage. The mixing stage which follows furnishes at the same time the intermediate frequencies for the sound and for the picture channel, a special mixing tube with built-in oscillator circuit being used (ACHI). This stage contains beside the oscillator circuits two strongly damped circuits, the antenna circuit and the intermediate circuit, both with variable self-induction so as to be able to cover the range 35 to 50 mc. for which television transmitters are planned with a separation of 1.8 mc.

The amplifier for the image consists of two stages: a resistance W_1 in the cathode lead of one of these i-f amplifiers allows adjustment of the brightness. The output is led to the oxide-coated electrode of the cathode-ray tube, the bias being adjusted with the aid of the resistance W_2 which controls the contrast in the picture. The band-width amounts to 1,400 kc. Despite this width the amplification per stage does not drop below 15, a result rendered possible through the use of intermediate frequency and band filter circuits with very low losses. The width of the sound channel is 29 kc. allowing an extremely faithful reproduction.

The deflection of the electron beam is obtained by means of a scanning stage to which the output of the image amplifier is fed. It rectifies first the image current and separates the image modulation from the picture—and line impulses. From a push-pull output stage these impulses are led to the deflecting plates.

The screen measures 19x22 cm. and is inclined 12° to the vertical. A single power transformer is used which supplies two rectifiers, a special power tube for the cathode ray and an ordinary power tube for the amplifiers. The cathode ray tube requires 5,000 volts; this potential is produced by means of a Greinacher circuit from 1,800 volt windings on the transformer. Despite the absence of voltage regulators the potential remains sufficiently constant.

The set possesses 13 tubes, 5 diodes and rectifiers, and one cathode ray tube. — *Fernsehen und Tonfilm* 6: 77-79. 1935.

THE EDITORS HAVE RECEIVED recently a descriptive folder from the Lorenz Company of Berlin (C. Lorenz Aktiengesellschaft) describing the television receiver illustrated (p. 48). The receiver is a combined sight-and-sound instrument designed for reception of television and voice signals on wave lengths of approximately 6.5 meters. Although the technical description does not give the number of lines or frame frequency, it is understood that the picture consists of 180 lines, 25 frames per second. A translation by Mr. Berthold Sheffield of the technical description is as follows:

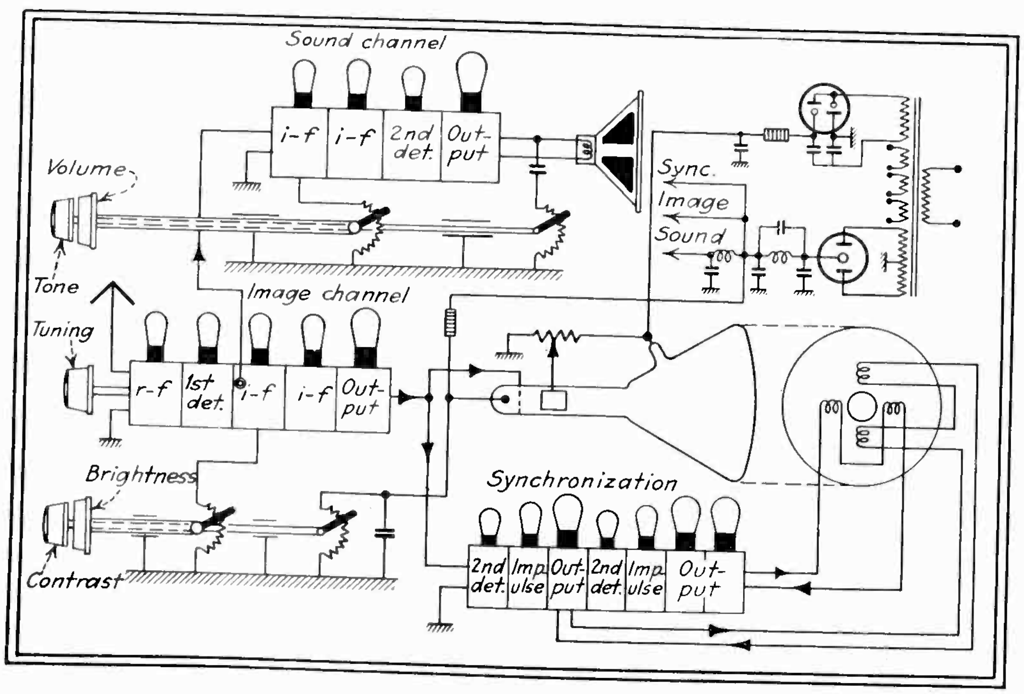
"The Lorenz television receiver operates with a high vacuum cathode ray tube, operating with a plate voltage of 5,000 volts. The electron beam is deflected in the vertical direction electromagnetically and by electrostatic means in the horizontal direction. Grid-controlled gaseous rectifiers (thyratrons), each followed by a single stage amplifier, generate the saw-tooth waves for the scanning and image-change. The television signals are received and amplified with a superheterodyne having four stages of intermediate frequency amplification, each stage having a band filter capable of passing 500 kilocycles with uniform amplification. A Braun tube serves as a second detector and its ray potential is controlled by the receiver.

"The synchronization signals contained in the received wave are filtered into image and line impulses, and are utilized for synchronizing the saw-tooth waves for image change and line frequency. The voice signal is received on a regenerative detector and two-stage audio amplifier feeding a dynamic speaker. The power supply for the entire apparatus is designed for a 220-volt line, and consumes approximately 330 watts.

"On the upper front panel (see illustration) of the receiver is the image screen, designed for a 19x22 cm. size image; below is the loud speaker opening. In the center are two pairs of control knobs. The pair on the left is for sound adjustment (tuning and regeneration). The right pair controls the image (tuning of the heterodyne in television receiver and input amplitude adjustment).

"On the outer right-hand side, below, is the master power (on-off) switch, controlling the entire receiver. In the rear are the power line plug, and bushings for connecting ground and antennas. Two antenna bushings are provided for connecting a dipole, which can be used advantageously when general receiving conditions are unfavorable. Ordinarily a simple short antenna connected to the upper antenna post is satisfactory for receiving at normal distances from the transmitter.

"The receiver is adjusted only by means of the two pairs of control knobs. Adjustments of the voice signal are made in the usual manner. The image controls are adjusted for



Schematic diagram of new Telefunken television receiver. Note separation of image and voice frequencies after first detector

in The SPOTLIGHT

. . . *a new* CENTRALAB *Product*

The Wave Change Switch, formerly made by PERFEX CONTROLS CO., of Milwaukee, Wis., is now a member of the famous CENTRALAB family. . . .

Leading manufacturers have "accepted" PERFEX Switches because of their positive biting contacts and their adaptability to all circuit requirements.

. . . and now under the CENTRALAB banner these wave change switches will, we believe, enjoy an even greater popularity. We welcome this new member to Centralab.

CENTRALAB — Division of Globe Union Mfg. Co., Milwaukee, Wis.

Centralab

CRL

Write Centralab for information on wave change switches, sockets, vibrators, controls and resistors.

This workmanlike television receiver, manufactured by the Lorenz A-G firm of Berlin, is now available to German buyers. As described (p. 46) it uses regeneration for voice, superheterodyne for television signals, on frequencies in the neighborhood of six meters

greater contrast and maximum sharpness. When the television receiver is improperly tuned, or when the transmitter is not operating, the image screen is dark. No other adjustments of the screen or of the image brightness are necessary. If the television receiver is properly tuned, then everything else automatically operates correctly. Once the television receiver has been so tuned, only the on-off switch need be operated for television and voice reception."

The announcement of the receiver contains the following interesting comment: The receiver is not available through the regular dealer distribution channels, since the success with which the receiver can be used depends upon the relation of the transmitter to the desired receiving location. Therefore, all those interested in obtaining one of the instruments are advised to get in touch directly with the manufacturer.

• • •

Non-linear Distortion by Band Pass Filters

[R. FELDTKELLER, SIEMENS LABORATORIES, BERLIN]. In the design of band pass filters the ideal aimed at is the flat top band, 6 to 10 kc. wide and preferably adjustable in width, the cut-off on both sides being extremely steep. With a finite number of circuit elements, however, a top which bulges upward in one hump, or in two humps with a sag at the center, at the resonance frequency must be accepted as inevitable, the slope being gradual on both sides of the band. This curvature causes several defects in the reproduction, namely weakening of the high notes when the transmission curve has the shape of a simple ridge, or weakening of the lower frequencies when the top has two humps. The phase differences between the frequencies at the center and near the edge of the band are in general negligible when the set is accurately tuned, but they produce distortion when the set is carelessly adjusted, or what is still more serious, when the band pass curve lacks symmetry, that is, when the filter transmits a frequency which is, say, 2,000 cycles above that of the carrier, better than a frequency which is 2,000 cycles below the carrier. A disagreeable twittering may then appear, phase modulation being produced in the band pass owing to the change in response with frequency.

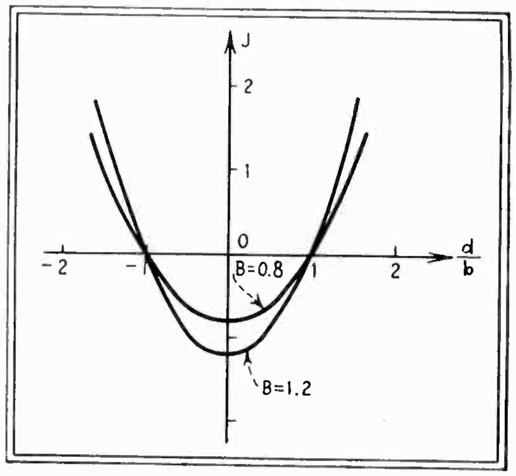
The influence of phase modulation in the band pass upon quality is best studied by graphical methods. When the band pass is connected between the plate of a tube and the grid of the following tube, the amplification factor being equal to μ and the internal resistance of the tube being r, the resulting voltage amplification is equal to

$$A = \mu \frac{Z}{Z + r}$$

where Z is the impedance (ohmic resistance R plus reactance jX) of the entire band pass. The band pass alone gives a definite ratio of input to output voltage, a ratio which differs in size and phase from frequency to frequency. Measured in suitable units, this ratio may in all practical cases be represented by a vertical parabola obeying the equation

$$A + \frac{d}{b} - jB + jB \frac{d^2}{b^2}$$

If P is the frequency at resonance or the carrier frequency, p the frequency which is being studied, d is the number of cycles off resonance, or equal to $p - P$, b is the frequency corresponding to the points where the parabola intersects the horizontal axis, as shown in the figure. When d is expressed in multiples of b, and B is given an arbitrary value, in practice a value between 0.5 and 1.5, the parabola is easy to draw for $A = 0$, remembering that the factor j means plotting on the vertical scale, while all the other values are measured on the horizontal scale. The curves need only be drawn so as to cover values of d/b between 0 and about 2, as in the figure. When a second value is assumed for B, and the parabola drawn, it will be found to lie deeper the higher the value of B, but all the curves pass through the two points $d/b = \pm 1$ on the horizontal scale.



Master parabolas for the design of band-pass filters

The line drawn from the origin of the system of coordinates to a point on the parabola represents in size and phase the ratio input to output voltage for the frequency d/b corresponding to this point on the horizontal axis. At the frequency $d/b = 1$ this ratio differs by 90° in phase from the ratio at $d/b = 0$ (carrier frequency); for any other frequency the phase difference is given by the angle which

TYPE 25X—¾ WATT

TYPE 15X—1.25 WATTS

TYPE 16X—1 WATT

S. S. White MOLDED RESISTORS

TYPE 70X—2 WATTS

TYPE 65X—1 WATT

TYPE 40X—¾ WATT

(Illustrations Actual Size)

At slight additional cost, any of these resistors will be supplied individually "noise tested" to the following exacting specification: "For the complete audio frequency range, resistors shall have less noise than corresponds to 1 part in 1,000,000."

RESISTORS of EXCEPTIONAL QUALITY

Featured by noiseless operation, rugged mechanical strength, non-hygroscopic material, permanent resistance value, these Resistors are available in two ranges:

FOR GENERAL COMMERCIAL APPLICATIONS
Standard Range: 1000 ohms to 10 megohms

FOR LABORATORY AND EXPERIMENTAL APPLICATIONS
High Values: 10 megohms to 1,000,000 megohms.

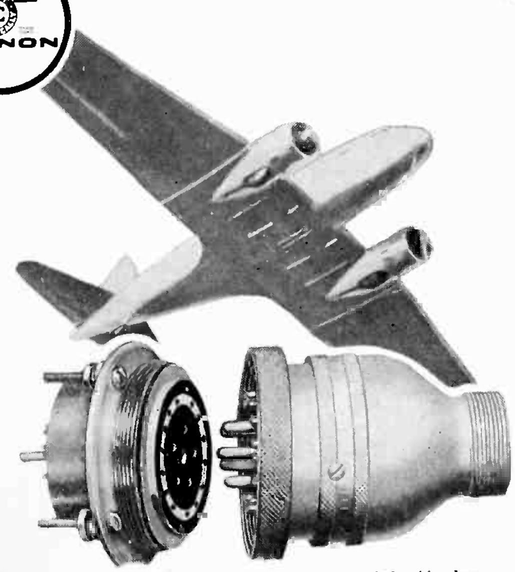
Declared by many users to be the most satisfactory resistors obtainable.

TRY THEM in your equipment. WRITE for descriptive circular showing types and giving wattage and resistance range.

The S. S. WHITE Dental Mfg. Co., INDUSTRIAL DIVISION

10 East 40th St., Room 2310E, New York, N. Y.

—there is NO substitute for Safety!



SAFETY is the conscious and sub-conscious goal of all air transport manufacture and operation . . . and, in pursuit of this goal, leading airplane manufacturers have standardized on CANNON Plugs. Likewise, leaders in every branch of the electronic industries put their faith in the ruggedness, efficiency and dependability of CANNON Plugs . . . plugs that insure not only safety but economy as well . . . plugs backed by a quarter of a century of experience combined with a highly specialized, personal service.

The Cannon Company takes pride in its ability to serve such clients as the following:

Write for General Plug Catalog or Special Airplane Plug Catalog.

American Airlines
Airplane Development Co.
Bell Telephone Laboratories
Blue Seal Sound Devices
Braniff Airways
Charlie Chaplin Studios
Columbia Studios
Columbia Broadcasting Co.
Curtiss-Wright Aeroplane & Mfg. Co.
Continental Theatre Accessories
Walt Disney Studios
Douglas Aircraft Company
Eastern Airlines
Electrical Research Products, Inc.
Fairchild Aerial Camera Corp.
Fox Film Corp. Studios
Geophysical Research Corp.
Geophysical Service, Inc.
Hearst Metrotone News
Hearst Radio, Inc.
Lockheed Aircraft Corp.
Glenn L. Martin Company
Metro-Goldwyn-Mayer Studios
Movietonews
National Broadcasting Co.
North American Aviation, Inc.
Northrop Corporation
North West Airlines
Pan American Airways
Paramount News
Paramount Productions
Pathe News
RCA Mfg. Co.—RCA Victor Div.
RKO Studios
Sikorsky Aircraft Corp.
Sperry Gyroscope Co.
Stinson Aircraft Corp.
Transcontinental & Western Air., Inc.
United Airlines
United Artists Studios
United Research Corp.
United States Navy
United States Army Signal Corps
Universal Pictures Corp.
Warner Bros.
Western Air Express
Western Electric Co.

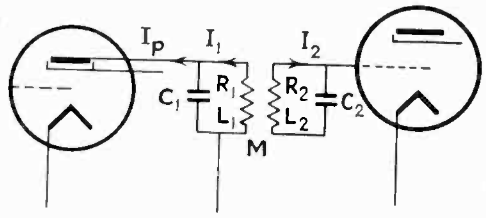
CANNON ELECTRIC DEVELOPMENT CO.

420 West Avenue 33, Los Angeles, California.

Eastern Sales Office: 220 Fifth Ave., New York, N. Y.

CANNON PLUGS

the line from the origin to the point on the parabola forms with the lower section of the vertical scale. The phase differences may therefore be plotted as a function of d/b for various curves differing by their value B. The length of the line from the origin to a point on the parabola divided by $-B$, which is the length corresponding to $d/b = 0$, gives the ratio of the voltage obtained at the frequency corresponding to the point selected to the voltage at the frequency $d/b = 0$, which latter voltage the a.v.c. tends to maintain at its value. These ratios are also readily plotted for various values d/b and for a few curves differing in B. The curves thus obtained illustrate immediately how flat the top is and where the cut-off begins. For instance, when B is taken smaller than 0.5, the filter curve has a single hump, and shows no flattening at the top. On the other hand, when B is equal to 1.4 some of the frequencies in the center are more than 3 db. below those at the edge, and low notes are unduly suppressed. When B is about equal to 1, the amplitude has dropped by about 5 db. with respect to the low notes at $d/b = 1.4$; if this drop is acceptable at $\pm 4{,}000$ cycles from the carrier ($d - 4{,}000$), b must be made equal to 4,000/1.4.



$$\frac{I_p}{jpC_1} = \left(R_1 + j\left(pL_1 - 1/pC_1\right)\right) I_1 + jpMI_2$$
$$0 = \left(R_2 + j\left(pL_2 - 1/pC_2\right)\right) I_2 + jpM_1$$

Band-pass filter and its equation

Taking, for instance (in place of the two stage amplifier with staggered circuits treated in the article) the case of an ordinary inductively coupled band pass, the ratio t, input to output voltage as measured across the condensers, is

$$-\frac{C_2}{C_1}\frac{I_p}{I_2} = \frac{C_1}{M}\left(R_1 + jX_1\right)\left(R_2 + jX_2\right) + p^2M^2)$$

where, as usual, $X = pL - 1/pC$ with p as the angular frequency $p = 2\pi f$. In the neighborhood of resonance, d cycles from the carrier $(R + jX)$, may for all modulated r-f waves (P much larger than d) be replaced by $R + 2jLd$ so that when the two tuned circuits in the filter have identical elements

$$(R_1 = R_2, L_1 = L_2, C_1 = C_2)$$
$$-t\frac{M}{C_1} = (R_1 + 2jL_1d)^2 + (P + d^2M^2)$$

On dividing by $4jL_1R_1b$, this equation becomes

$$\frac{t}{t_1} = -\frac{d}{b} + \frac{4jL_1}{R_1}b\frac{d^2}{b^2} - j\left[\frac{R_1}{4bL_1} + \frac{P^2M^2}{4bR_1L_1}\right]$$

where $t_1 = 4jR_1L_1C_1b/M$. This expression is equal to that for the master parabolas if t is measured as a multiple of t_1

$$B = -4b\frac{L_1}{R_1} = -\frac{R_1^2 + M^2/L_1C_1}{4bR_1L_1}$$

$$\text{or } 4b^2 = \frac{R_1^2 + M^2/L_1C_1}{4L_1^2}$$

In the example cited R_1, L_1, M would have to be so chosen that b is about 2,960. At the same time B should not exceed about 1.5 in absolute value; else the average listener may not be able to tune the rceiver with sufficient accuracy to avoid distortion. It would be a help to him if before programs deserving high fidelity, a signal modulated by 1,700 and 2,500 cycles were sent out. The listener would so adjust his set that the combination tone of 600 cycles disappears.—*H. Fr. Tech. El. Ak.* 46: 133-140. 1935.

• • •

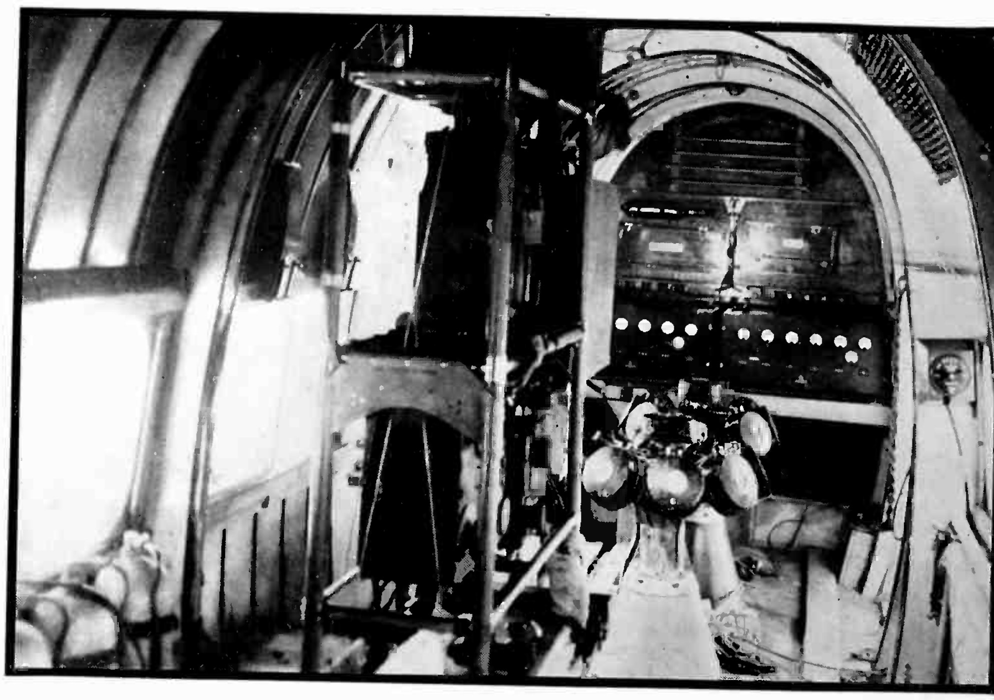
Nature of Metal Surfaces Revealed by Electron Diffraction

The "Transactions of the Faraday Society" for September, 1935, contain the reports presented at a special international meeting called for a general discussion of the structure of metal surfaces and of metal coatings as brought to light by the diffraction of electrons. While X-rays penetrate so deeply as to reveal the structure of the inner layers, they disregard the surface film with which the metal becomes covered in air, or which the metal forms in contact with air. The low penetration of the electrons allows the study of this film, even if it be so thin as to produce no interference colors. Whether the surface layer of a polished surface consists of crystals broken into fragments, or of an amorphous glassy layer, long a subject of investigation, is decided by tests with electrons in favor of the glassy film, the Beilby layer, about 30 Å. thick. Electron diffraction effects are also useful in the study of metal films.

The rings obtained by diffraction in commercial gold foil, are sometimes complete and suggest that the crystals are at random; usually, however, the crystals in rolled or beaten metals display a certain degree of orientation. Suitable heating in air not only increases both the crystal size and orientation, but also brings into prominence extra rings or bands or both.

Electron diffraction reveals the growth of crystals in thin foils. Some metals respond more readily to heat treatment than others; while gold is rather sluggish, aluminum readily forms single crystals; thus, quickly drawing a thinned commercial aluminum foil through the hot gases of a Bunsen flame increases both size and orientation of the crystals, as shown by the short arcs and many little spots distributed along the diffraction pattern.

LOUDSPEAKING AIRPLANES POLICE WILD TRIBES



Two clusters of dynamic loudspeaker units are fitted to horns in the fuselage of this British airplane which is used in policing tribal areas in Iraq. Orders and warnings from planes seem to be much more effective than the use of force

MANUFACTURING REVIEW

Names in the News

✦ **Edwin Jay Quinby** has joined the public relations department of the Western Electric Company in an

editorial capacity. Mr. Quinby was formerly a member of the publicity and advertising department of RCA Victor, where he founded and edited that company's sales publication "Broadcast News." Prior to that time he served in an engineering capacity on the staff of the Bell Telephone Laboratories. Mr. Quinby is located at the company's headquarters at 195 Broadway, New York City.

✦ **Maximilian Weil** announces a prize contest to determine the name of a new pick-up the Audak Company, 500 Fifth Avenue, New York, has developed. This new instrument is said to have eliminated the factor of moving mass which has militated against perfect reproduction. In it the vibrating armature has been made stationary. A first prize of $100 is offered for the name selected; there are five consolation prizes as well.

✦ **Centralab, of Milwaukee, Wis.**, manufacturers of volume controls, sound projection controls and fixed resistors announces the purchase of the Perfex Controls Co., of Milwaukee. The Perfex organization has made a line of wave change switches and other radio products and this marks the entry of Centralab into the wider field.

✦ **Thomas N. Armstrong, Jr.**, has joined the technical staff of the International Nickel Co., Inc. Mr. Armstrong, who will handle the steel castings development for the company will operate out of the New York office at 67 Wall St.

✦ **Columbia Broadcasting System** reports business billed in December at $1,885,977, an increase of 12.7 per cent over billings for December, 1934. The yearly billing for 1935, in the amount of $17,637,804 shows an increase of 19 per cent over the billings for 1934.

✦ **H. M. Wilcox**, has resigned as vice-president of the Electrical Research Products, Inc. Mr. Wilcox has been on leave of absence recently, serving in an advisory capacity in Paramount Pictures, Inc.

✦ **The "Design Laboratory,"** located at 10 East 39th St., New York City is a recently established WPA project which should be of interest to those interested in industrial textile or ceramic design as well as the regular graphic arts. Detailed information may be secured from Gilbert Rohde, with offices at the above address.

✦ **Hygrade Sylvania Corporation** has made several important changes in the personnel of its tube sales department. Paul S. Ellison, Advertising Manager of the radio tube division, becomes Sales Supervisor of this district. R. P. Almy, Charles G. Pyle, A. L. Milk and H. G. Kronenwetter have become increasingly important in this division of the Sylvania organization.

✦ **Toledo Synthetic Products, Inc.**, Toledo, Ohio announces a change in their company name, effective January 1 of this year. The new name of the company is Plaskon Co., Inc.

✦ **Shure Brothers Co.**, 215 W. Huron St., Chicago, recently announced that an increase in the demand for their products necessitated a considerable enlargement of both factory and laboratory facilities. An interesting addition is an improved low-reverberation sound room for acoustic measurements.

✦ **J. J. Sally** is now representing the Crowe Name Plate & Manufacturing Co. in the Philadelphia territory. Mr. Sally will give particular attention to the radio field. His offices are in the Terminal Commerce Building, 401 N. Broad Street, Philadelphia.

New Products

Tubing

The Summerill Tubing Company, Bridgeport, Pennsylvania, through improved technique in recent months offers 1-inch tubes with walls as light as .006 in. Somewhat smaller diameters have been made with walls as light as .004 in.

This same company has recently produced seamless nickel tubing .005 in. with a .0008 in. wall.

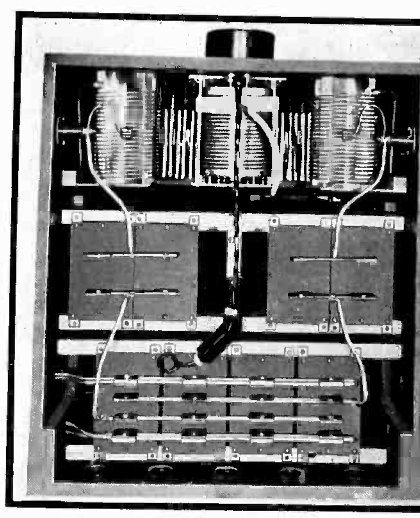
The alloys employed in making these tubings are of the chrome molybdenum series, which long experience has proven to possess high fatigue limits.

Controlled Rectifiers

Ward Leonard Electric Company, Mount Vernon, New York, announces the development of controlled rectifiers to supply a d-c output from a commercially constant, single phase, 110 volt a-c line. The output voltage regulation is plus or minus 2 per cent from approximately one-tenth to full load. On all sizes that cover a range from 30 watts to 250 watts, the efficiency is better than 50 per cent and the power factor better than 65 per cent.

Converter

Lepel High Frequency Laboratories, Inc., 39 West 60th St., New York City, announces a new model "C-4" 5 kva. converter. This unit is designed to operate from a 220 volt, 60 cycle single phase supply line. This converter has a frequency range from 160 kc. to 500 kc. and will supply a current of 140 amperes at 316 kc. through 6 microhenries. This converter is of the tungsten quenched gap type having a



variable frequency, primary exciter circuit which is tuned and coupled to a low loss tank circuit. Its overall dimensions are 23½ in. front, 25½ in. deep and 37½ in. high.

WRITE for BULLETIN

on this *New* DUAL DIAPHRAGM CRYSTAL MICROPHONE

The DUAL DIAPHRAGM is a new principle of interior Crystal Microphone construction, exclusively offered by Astatic, which gives you

- exceptionally fine frequency response.
- a greatly reduced feed-back tendency.
- clear, sharp reproduction under any pick-up condition and is NON-DIRECTIONAL.
- less interference from associated parts.

ASTATIC

Dual DIAPHRAGM

MODEL K-2

A GRAPHOIL BIMORPH CRYSTAL is used in the construction of Model K-2 under license of the Brush Development Company, Astatic patents pending. Ruggedly constructed and guaranteed—list price $37.50—especially recommended for broadcast studios and public address systems.

ASTATIC MICROPHONE LABORATORY, Inc. YOUNGSTOWN, O.
Pioneer Manufacturers of Quality Crystal Products

THE FACILITIES OF

ELECTRONIC LABORATORIES

ARE AT YOUR DISPOSAL

ALL the vast experience gained by Electronic engineers in years of designing and manufacturing 6, 12, 32 and 110 volt power units is at your service—without cost or obligation—for helping you solve your own special power supply problems. We will be glad to recommend the unit best suited to your needs, or if necessary design and build a special power supply unit to meet your exact requirements, if you merely send us specifications and complete details as to the use to which the unit is to be put. Write or wire for further information about this special Electronic engineering service.

ELECTRONIC LABORATORIES, Inc.
Indianapolis, Ind.

PRESTO

INSTANTANEOUS RECORDERS

Accurately engineered for maximum utility. The compact portability plus high fidelity characteristics of the Presto Recorder, make it an asset to the finest studio.

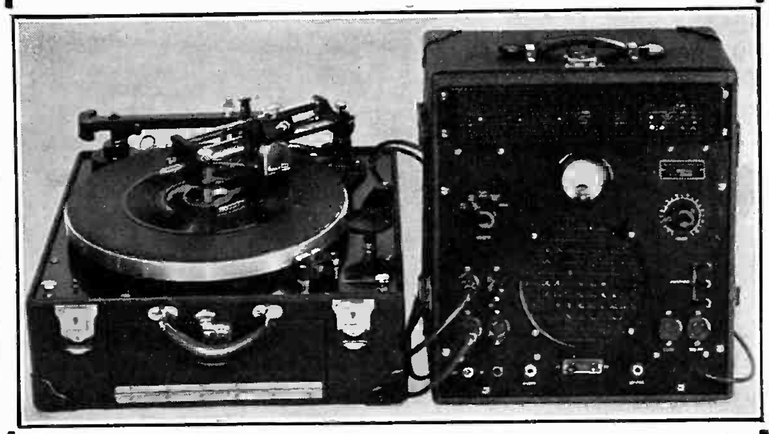
The flexibility of the machine combined with its compactness (one man can carry it), permit the use of the Recorder in the most difficult positions.

COMPACT *PORTABLE*

One plug to attach to the power supply, one flip of the switch and the Recorder is ready for operation. Another flip of the same switch and the recorded material can be promptly played back.

Although comparatively inexpensive, the replacement of expensive installations by the Presto Recorder, and elimination of duplicating apparatus will quickly amortize the initial investment.

RECORDING EQUIPMENT IN ITS MOST CONVENIENT FORM



PRESTO *GREEN SEAL* DISCS

For maximum results use *Presto Green Seal Discs*. Adaptable to any machine, the Green Seal Disc, chemically coated on an aluminum base, has been acclaimed as the finest development in the transcription field. Try one, on the very next job! Its outstanding performance will prove the Disc's worthiness. Super-sensitive surface of discs is protected against climatic conditions, by air tight metal shipping container. Discs are kept indefinitely fresh—ready for recording at any time. Packed in quantities of twenty-five.

All Presto equipment unconditionally guaranteed. If apparatus does not meet with your expectations return within 30 days and money will immediately be refunded.

EVERYTHING FOR RECORDING FROM A NEEDLE TO A COMPLETE STUDIO INSTALLATION.

California Distributor
Norman B. Neely, 1656 No. Serrano Street, Los Angeles, Calif.

PRESTO

RECORDING CORPORATION
139 West 19th Street, New York, N. Y.

Low Capacity Electrostatic Voltmeter

SENSITIVE RESEARCH INSTRUMENT CORPORATION, 4545 Bronx Boulevard, New York City, has an improved low capacity electrostatic voltmeter. Its new design magnetic damping of the pointer

makes a shorter period, faster reading instrument. This design is available in full scale voltages from 30 volts to 40,000 volts (accuracy 1%) in single, double or triple ranges.

New Battery Pentode

HYGRADE SYLVANIA CORPORATION, 500 Fifth Avenue, New York City, announces a battery type pentode, Type 1F4, for use as a power pentode in battery type sets.

E_f 2 volts; I_f 120 ma.; I_p 8 ma.; I_{sg} 2.6 ma. μ340; R_p 200,000 ohms; g_m 1700 micromhos; R_o (load resistance) 16,000 ohms. Base same as type 33. ST-12 glass bulb. With 3.5 volts r-m-s signal on the grid will deliver 340 mw. with 5 per cent distortion.

Anti-Friction Molding Material

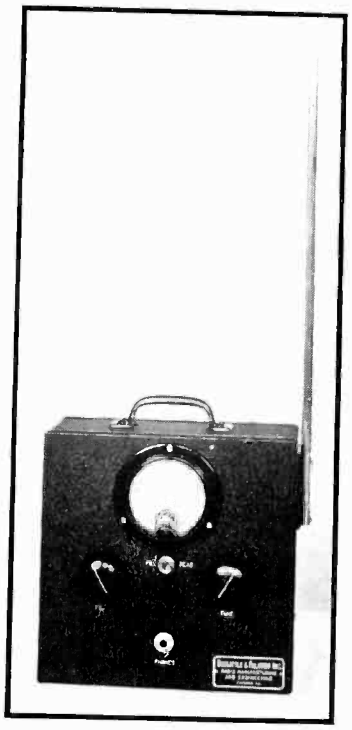
A NEW FRICTION resistant material, a new Durez development called 1564, is offered by General Plastics, Inc., North Tonawanda, N. Y. This contains 10% graphite and has an impact strength of roughly 40% greater than ordinary materials. One of its most interesting features is the small bumper shoe which bears against the metal wedge on the new motor car doors, supporting them and preventing rattling.

Sound Cell Microphone

MODEL BQS, a low priced microphone made available by the Brush Development Co., Cleveland, Ohio, with an output level of minus 66 db. This line of microphones is small in size, light in weight and sufficiently rugged in construction to be impervious to severe changes in atmospheric conditions or to mechanical stop or wind pressures. These microphones are designed to operate directly into the grid of the first tube, thus eliminating the use of input transformers and pick-up hum.

Field Strength Indicator

A FIELD STRENGTH METER for use between 30 and 45 megacycles has been designed by Doolittle & Falknor, Inc., 7421 South Loomis Blvd., Chicago, Ill. This can be supplied for any specified frequency from 1 to 100 megacycles with no increase in cost. The sensitivity of the instrument may be changed by changing the length of the antenna. Power is supplied by one No. 6 dry



cell, mounted inside. This instrument is particularly useful in adjusting or routine testing of transmitters in police cars. A jack permits the insertion of headphones in order to check the quality of modulation of the transmitter. The meter indicates carrier shift and in this way it may be used as an overmodulation indicator. It sells at $35 f.o.b. Chicago complete with tube and battery.

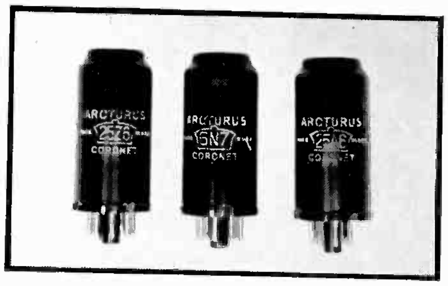
Pick-ups

AUDAK COMPANY, 500 5th Ave., New York City announces a high range professional electro-chromatic pick-up used in radio stations. The arm is of special length to accommodate records up to 18 in. in diameter, and is counterbalanced by dead weight. The arm is made of special heavy gage aluminum.

This instrument is designed for use with higher range recordings. It works with low needle pressure. It is immune to humidity and temperature changes.

New Tubes

ARCTURUS RADIO TUBE COMPANY, 720 Frelinghuysen Avenue, Newark, New Jersey, has added three tubes to its "Coronet" line. Type 6N7 is a Class "B" complete output tube. It can, in



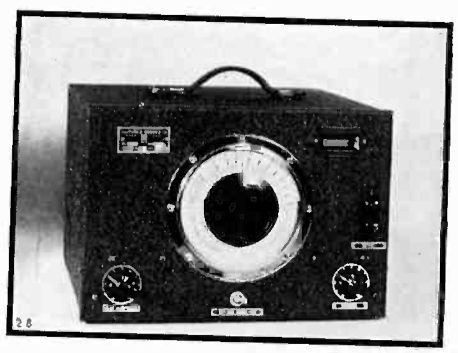
addition, be used in the driver stage as a Class "A" amplifier for driving the input circuit of a 6N7 operating as a Class "B" amplifier. The 25A6 is a 25.0 volt output tube, identical to the type 43, and is for use in ac-dc receivers. The 25Z6, identical in characteristics to the 25Z5, is a 25.0 volt full-wave rectifier for ac-dc operation.

HYGRADE SYLVANIA CORPORATION, 500 Fifth Avenue, New York City, announces the addition of type 25A6 and 25Z6 to their metal tube line.

RAYTHEON PRODUCTION COMPANY, 30 East 42nd Street, New York City, has announced the addition to their line of all-metal tubes the 6R7, corresponding to the glass type 85. It has a plate resistance of 8,500 ohms, permitting the use of a transformer coupling to a high quality output stage. Its power output is 280 milliwatts; its dimensions and base connections are equivalent to the 6Q7; it is especially useful in high-fidelity receivers.

Portable Audio Oscillator

A NEW, COMPACT, portable beat-note audio oscillator is announced by the Clough Brengle Co., 1134 W. Austin Ave., Chicago, Ill. This oscillator listed as model 79 is variable from 0 to 10,000 cycles per second and the output voltage is uniform within 2 db., from 50 to 10,000 cycles output potential of



27 volts is developed at 5,000 ohms impedance, sufficient for direct coupling to tube grids. The model 79 is operated directly from a 110-volt, 60-cycle power line. The net price complete with tubes is $51.90.

a New Crystal Pick-up by WEBSTER ELECTRIC

fitting companion to the well-known and widely-used magnetic type . . .

● When the Webster Magnetic Type Pick-up was introduced to the field, its performance characteristics met the approval of the most critical.

The new Webster Crystal Pick-up is destined to receive the same enthusiastic approval.

For this new pick-up embodies the precise design, the engineering skill and the careful craftsmanship so essential to fine performance in sound reproduction apparatus.

The Webster engineers have applied a new adaption of theory in the design of this new pick-up which provides the very ultimate in high frequency response with a minimum of needle noise.

The Webster Crystal Pick-up has many design features—some of which are listed to the right. It is available for use with both standard and 16-inch records in both standard and high fidelity response.

Literature which describes it in detail will be mailed you upon request.

Licensed under patents of Brush Development Company

FEATURES

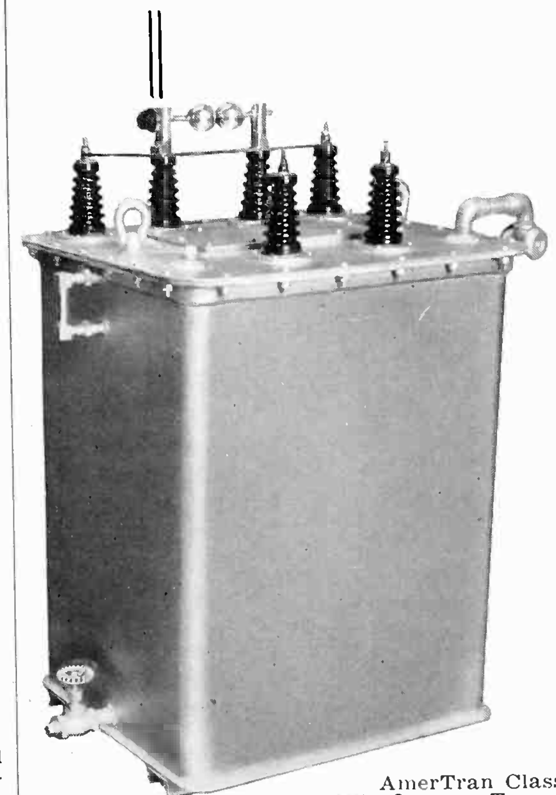
1. Compact with light needle weight on record.
2. Free from resonance.
3. Lower scratch and distortion level.
4. Low mechanical needle point impedance.
5. Chatter Proof — wear-resisting mechanical construction.
6. Moulded-in screw terminals—no soldering required. (Avoids possible damage to crystal from heat.)
7. Double sealed against moisture.
8. Built-in volume control (or without).
9. Compensated frequency response (standard or high fidelity).
10. Range of voltage output up to 1.5 V. at 1000 cycles.

WEBSTER ELECTRIC COMPANY
Established 1909
RACINE . . . WISCONSIN, U. S. A.
Export Office
15 Laight St., New York City

Wherever Sound W Must Fill Great Spaces

WEBSTER • • ELECTRIC

There must be a reason for the popularity of AMERTRAN MODULATION SETS



AmerTran Class "B" Output Transformer for +65 dB level.

WITHOUT fear of contradiction, AmerTran is proud to claim that it has furnished a large majority of all class "B" modulation sets used in the larger American broadcast stations. Such equipment has been supplied to all sizes of stations from 100 watts to 500 kilowatts.

The successful results obtained with AmerTran equipment explain its great popularity. Actual tests on these transformers show an insertion loss of less than 1 dB and frequency characteristics uniform within ±1 dB from 30 to 16,000 cycles.

May we send engineering details on a modulation set to meet your needs?

AMERICAN TRANSFORMER CO.
Transformer builders for over 34 years
180 EMMET ST., NEWARK, N. J., U. S. A.

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Ribbon Microphone and Casing

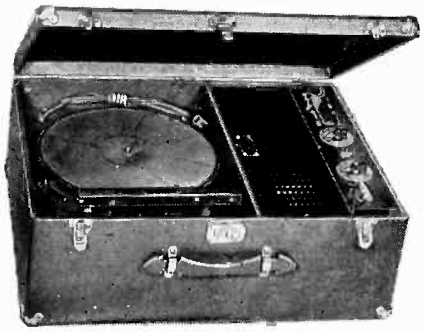
A RIBBON MICROPHONE housed in a new style futuristic black enamel and chrome polished casing has been developed by the Universal Microphone Company, Inglewood, Calif. This compact microphone weighs 1½ lb. with dimensions of 2¾ x 4¾ and 1 in. in thickness. This new line has been designed for all-round radio use including broadcast studios, remote control points, public address work and other purposes in the field. The case can be hinged on swivel joints for greater ease in handling. This microphone lists at $22.50 plus the plugs.

Transmission Cable

ARTHUR H. LYNCH, INC., 227 Fulton Street, New York City, announces the improved Giant-Killer Cable, for use either in receiving or transmitting. This cable has a rugged outside wall which may be easily rolled back to expose the Laytex covering. This Laytex covering, in turn, is so elastic as to permit its being rolled back and replaced after the two conductors are soldered. This twin conductor has a surge impedance of approximately 70 ohms, which matches the impedance of any half-wave antenna.

Universal Bridge

RCA MANUFACTURING COMPANY, Parts Division, Camden, New Jersey, adds to its line of test equipment a variable ratio arm a-c wheatstone bridge that will measure inductance from 100 mh. to 10 henries, capacity 10 mmf. to 10 mf. and resistance from 1 ohm to 1 megohm with an accuracy of five per cent at full scale. It is adapted for service engineers, experimenters, laboratory workers and manufacturers.



Portable Public Address System

A PUBLIC ADDRESS system specially designed for lecturers, salesmen, political talkers and others requiring musical interludes between speeches, is offered by the Lafayette Radio Mfg. Co., Inc., 100 Sixth Ave., New York City. The phonograph turntable, amplifier and mixing panel for control are included in a single fabrikoid covered carrying case. The dynamic loud speakers are contained in a separate case. Model 530-P uses a 12-watt amplifier and is adapted for use with crystal microphones. Lists at $57.50, less speakers, tubes and mike. Model 531-P, employing a 16-watt, lists at $69.50, less speaker, tubes and mike. The two different grades of speakers available are listed at $35.70 and $44.00 respectively.

• • •

Literature

THE following catalogs and manufacturers' bulletins have recently been received:

✦ **Power Equipment.** A new catalog section to be included in the larger loose-leaf binder of the American Automatic Electric Sales Co. has just been released. This section deals with power equipment for small communication systems and contains descriptions and illustrations of their battery eliminators, direct current charging units, full wave rectifiers, converters and kindred products.

✦ **Tachometers.** A catalog issued by the James G. Biddle Co., of Philadelphia, with complete descriptions, uses and advantages, and prices of their line of speed indicators.

✦ **Radio and Sound Equipment.** A complete listing and description of the radio parts and accessories offered by the Federated Purchaser, Inc., with offices in New York City, Chicago and Atlanta, Ga.

✦ **Collins Signal.** The December issue of the Collins Radio Company's house organ with an article on Multiband Antenna for High Frequencies and the calculation and measurement of transmission line loss, the latter illustrated with a page of helpful charts.

✦ **Tube Testers.** A booklet on the evolution of tube testers is offered to the industry by the Supreme Instrument Corp., of Greenwood, Miss., manufacturers of radio test instruments. This is a booklet of technical data on various types of tube testing circuits and is supplemented by a number of diagrams, and takes the reader through many of the problems of research in early laboratory stages.

✦ **Plastic News.** The newest member of the Durez family of publications is Durez Plastics News, carrying descriptive material on the subject of plastics and photographs of its varied applications. Published by General Plastics, Inc., North Tonawanda, N. Y.

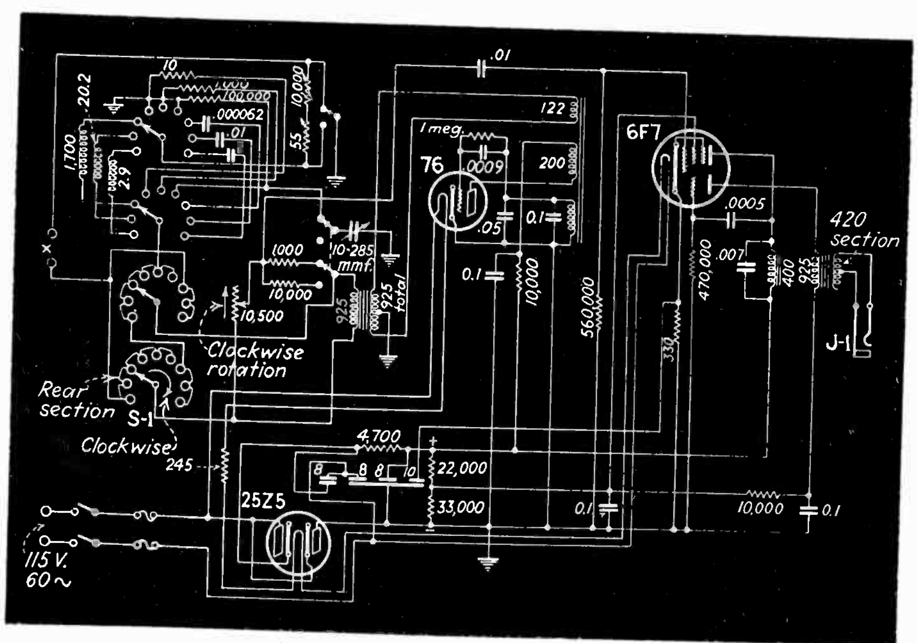
✦ **Tantalum.** A 48-page book of technical information about Tantalum and its uses, issued by the Fansteel Metallurgical Corp., of North Chicago, Ill. Copies of this book will be supplied without charge upon application to the manufacturers.

✦ **Condensers.** A catalog describing and illustrating available Cornell-Dubilier condensers and condenser replacements. Issued by the Cornell-Dubilier Corp., 4377 Bronx Blvd., New York City.

✦ **Disc Recording.** "Advanced Disc Recording" published by the Universal Microphone Co., Ltd., Inglewood, Calif. A small booklet, priced at 10 cents a copy, giving a complete theory of the art of disc recording.

✦ **Inco.** The recent edition of the International Nickel Company's magazine with articles dealing with the application of nickel and nickel alloys in their various forms. Publication offices 67 Wall St., New York City.

✦ **Meter.** A descriptive booklet from the Hoyt Electrical Instrument Works, playing up the unusual design of their new square meter, with the angular scale (described in January *Electronics*) permitting greater readability of the sub-divisions because of its angular scale.



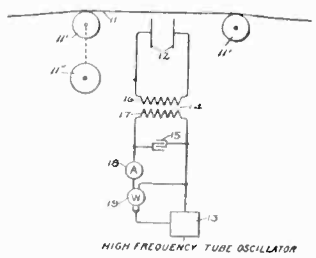
RCA universal bridge circuit

PATENTS REVIEW

PATENTS indicate trends. Next year's radio circuits, applications of electron tubes for non-communication purposes, new tube types, new materials, may be discovered by following United States and British inventions.

Electron Tube Applications

Tube control. The following patents have been assigned to the G.E. Co.: No. 2,021,766, M. E. Bivens, electronic timer. No. 2,021,760, W. R. Whitney, moisture indicator. No. 2,023,217, scanning apparatus, F. A. Benford. No. 2,023,343, a control system for performing operations on a moving strip of material; T. R. Rhea and L. A. Umansky. No. 2,023,228, magnetic flux



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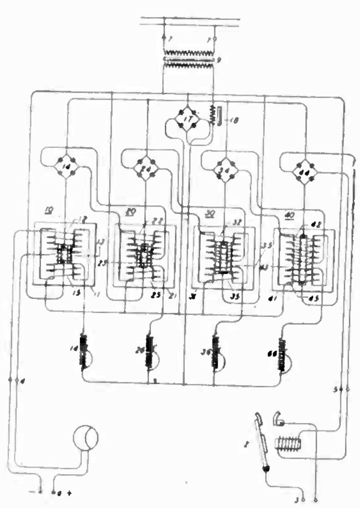
generation and magnetic testing; P. C. Hermann. Nos. 2,025,083 and 2,025,584 to A. S. FitzGerald; a regulating system including a direct current circuit for controlling an electrical characteristic of an alternating current circuit. No. 2,027,140, a torque amplifying system to E. F. W. Alexanderson. No. 2,019,352 to O. W. Livingston, and 2,027,209 to F. M. Starr on control of electric circuits.

Magnetic amplifier. Patent Nos. 2,027,311 and 2,027,312 to A. S. Fitz-



Gerald, Wynnewood, Pa. See also 2,026,124 to FitzGerald on automatic regulating system.

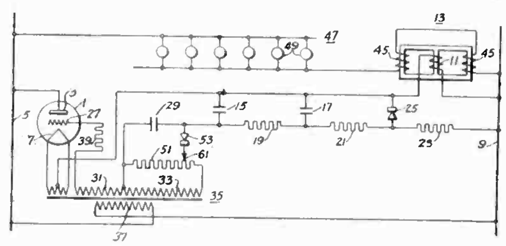
Crystal grinding. A tube method for automatically grinding crystals. M. E. Strieby, B.T.L., Inc. No. 2,023,494.

Size determination. Combination of a cutting tool, means for holding the workpiece, a glow tube for energizing an electromagnet adapted to bring about the separation of the tool in the workpiece. H. L. Blood, Heald Machine Co., Worcester, Mass. No. 2,023,662.

Biasing circuits. No. 2,024,152 to G. R. Eaton; 2,024,181 to J. H. Philips. No. 2,024,139 to H. M. Armstrong, Kellogg S.&S. Co.

Power control. The following patents have been assigned to Cutler-Hammer, Inc., Milwaukee: No. 2,024,542, Arthur Simon, a timing device. No. 2,025,911, Carroll Stansbury, an inverter circuit. No. 2,024,838, C. Stansbury, an electrical control circuit.

Relay circuits. The following patents have been assigned to Westinghouse E&M Co.: No. 2,027,239 to T. H. Long



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on a grid-glow position relay combination. No. 2,020,917 to P. E. Stogoff on a photo-sensitive relay. No. 2,027,253, a flasher circuit to W. W. Viebahn. Impedance relay, No. 2,027,226, to S. L. Goldsborough. Reissue No. 19,807 to F. H. Gulliksen, a regulator compensator for a dynamo-electric machine. See also No. 2,023,084 to J. F. Kovalsky, a regulating system, and No. 2,021,888, J. W. Dawson. No. 2,023,106 to S. A. Staege, a regulator for controlling the consistency of material by controlling the amount of liquid added. No. 2,024,708 to S. A. Staege, electron tube type tension regulator.

Generator control. Network of inductances, resistances, etc., between a generator and a cathode of a control tube to give a predetermined regulating characteristic for all magnitudes of current and power factor. L. C. Verman and L. A. Richards, RCA. No. 2,021,161.

Thermostat. An oscillating circuit whose natural frequency varies with the temperature. H. Muth, Telefunken. Company, Berlin, Germany. No. 2,027,193.

Transmission system. Method of transmitting power by means of direct current at abnormally high voltages. R. J. Van de Graaff, Research Corp., New York. No. 2,024,957.

Control circuit. A transformer supplying control voltage to the grid of a grid controlled gaseous rectifier. A means is supplied for dissipating the voltage induced in the transformer by the cessation of the gaseous discharge. D. V. Edwards, Electrons, Inc. No. 2,021,482.

Relay. Circuit using a pair of glow discharge devices connected in series, a variable impedance in shunt to one of the devices, etc. H. C. Thompson, G.E. Co. No. 2,021,034.

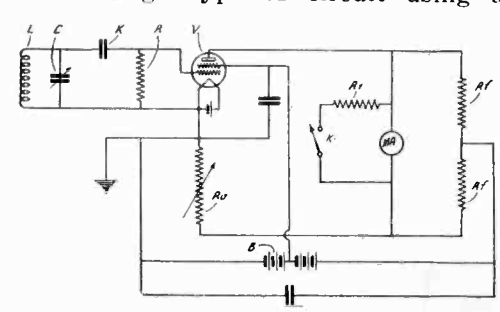
Power conversion. Tube apparatus for transmitting energy from a d-c supply circuit to an a-c load. W. Petersen, G.E. Co. No. 2,026,358.

Current regulator. A multi-phase system by which current variations in the load circuit are translated into mechanical motion whereby the current to the load is restored to normal. H. E. Young, Chicago, Ill. No. 2,021,216.

Corrosion preventive. Method for automatically compensating for corroding currents varying fortuitously in magnitude and polarity by grid controlled space discharge tubes. H. S. Polin, Polin, Inc., New York, N. Y. No. 2,021,519.

Titration apparatus. Apparatus for carrying out electrometric analyses by using a calomel, a silver, and platinum electrode. Udo Ehrhardt, I.G.F.A., Germany. No. 2,024,819.

Vacuum tube voltmeter. A Wheatstone bridge type of circuit using a



four element tube, No. 2,027,195 to T. D. Parkin, RCA.

Contour control. Machine for reproducing a pattern contour on a workblank in which control is effected by a light sensitive relay in combination with a vacuum tube amplifier. E. D. Lilja, Rockford, Ill. No. 2,025,062.

GOAT makes the PARTS that make the INDUSTRY

GOAT RADIO TUBE PARTS INC

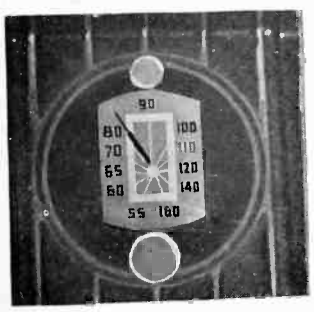
A DIVISION OF THE FRED GOAT COMPANY • INC • Established 1893

314 Dean St., Brooklyn, N. Y.

KAY—NEW *Universal* CUSTOM INSTRUMENT-PANEL REMOTE CONTROL UNIT

One KAY CONTROL HEAD fits all 1935-1936 Cars

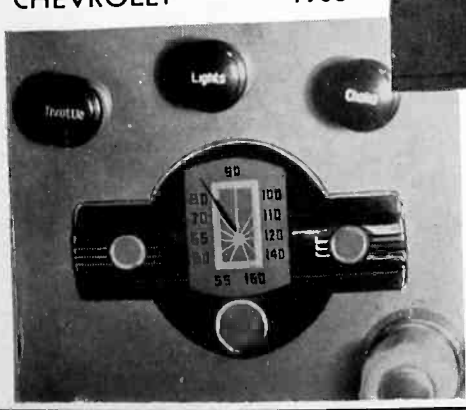
KAY CONTROLS will increase your sales of auto-radio receivers



Above
FORD 1935-1936
LINCOLN-ZEPHYR 1936

Right
PLYMOUTH 1936

Below
CHEVROLET 1936



DISTINCTIVE KAY FEATURES:

- Takes "gamble" out of your cost of remote controls.
- No need to tie up sets labeled for specific cars.
- Handsome "wrist-watch" design.
- Airplane dial—perfect tuning.
- New INDIRECT pilot lighting.
- Escutcheons match every car.
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- Steering post and under dash fittings also available.

MANUFACTURERS: *Write at once for complete details on KAY Remote Controls and Escutcheons. Equipped to efficiently handle special jobs — may we quote on your specifications?*

KAY PRODUCTS of AMERICA, Inc.
562 DE KALB AVE. BROOKLYN, N. Y.

Light control. A light collecting and contributing system employing hollow conical shaped collectors, reflectors, etc. A. M. Nicholson, Communication Patents, Inc. No. 2,022,144.

Electrical musical instrument. Three patents assigned to Miessner Inventions, Inc. No. 2,027,073 to O. Vierling. No. 2,027,074 to B. F. Miessner, and No. 2,027,075 to C. T. Jacobs, Milburn, New Jersey.

Control system. Arthur Pfister, RCA. No. 2,027,196.

Displacement measurement. Vacuum tube oscillator, a double condenser, a body capable of displacement and connected with the condensers so as to change their capacity simultaneously and oppositely due to the displacement. L. W. Blau, A. B. Bryan and W. D. Mounce, Standard Oil Development Co. No. 2,025,719.

Radio Receivers

A.v.c. circuits. No. 2,025,019 to F. M. G. Murphy, to RCA. L. M. Perkins, No. 2,026,357 to RCA, and No. 2,017,977 to H. Ladner to A.T.&T. Co. No. 2,022,478 to H. O. Peterson, RCA.

Automatic program indicator. A movable printed sheet, a sight window, clockwork apparatus, etc. E. A. Zadig, New York, N. Y. No. 2,024,195.

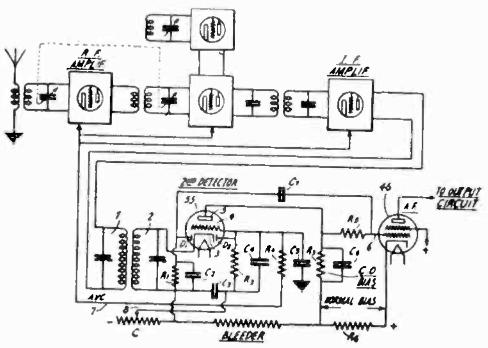
Input circuit. Three series resonance type tuned circuits conductively coupled in parallel as a pre-tuning system as a means of getting 10 kilocycle tuning. J. L. Adams, Jr., Youngstown, Ohio No. 2,024,902.

Tone control. A series connected resistance and condenser, the resistance being variable as an interstage coupling device. L. F. Curtis, United American Bosch Corp. No. 2,026,495.

Superheterodyne receiver. No. 2,022,447, A. M. Wengel, Madison, Wis. No. 2,022,085, J. K. Johnson, Hazeltine Corp. No. 2,022,068, H. A. Wheeler, Hazeltine Corp. Reissue, No. 19,765, D. E. Harnett, Hazeltine Corp. No. 2,024,017, H. A. Wheeler, Hazeltine Corp. No. 2,024,807, J. D. Reid, RCA. No. 2,024,614, C. B. Terry, RCA. No. 2,020,832, David Grimes, RCA. No. 2,026,759, A. H. Turner, RCA.

Radio Receiver Controls

Volume control. Patents to J. S. Starrett, Nos. 2,023,448 and 2,023,449; W. R. Koch, No. 2,021,939; No. 2,023,458 to Jacob Yolles. All assigned to RCA on quiet automatic volume control systems. No. 2,026,102 to A. Senauke, Hazeltine Corp.



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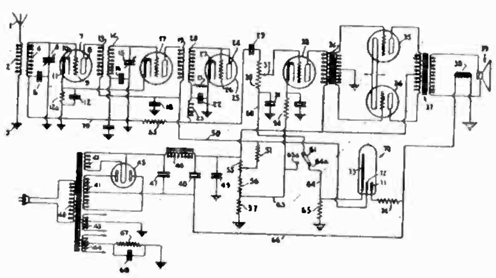

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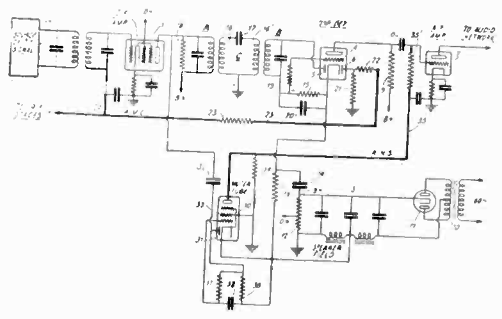

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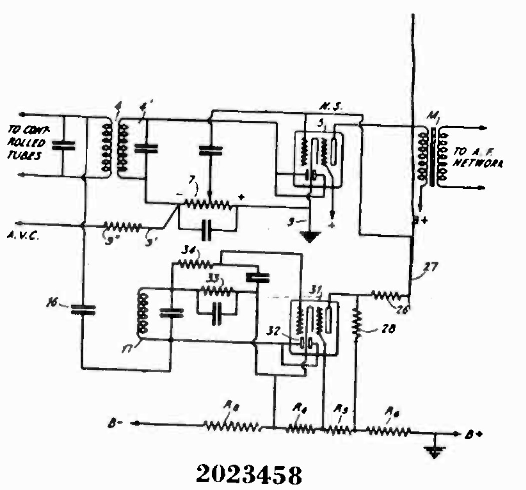

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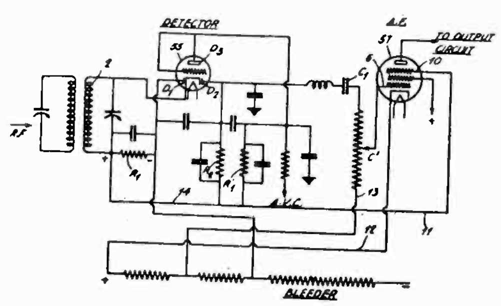

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Patent Suits

1,647,710, 1,647,711, H. E. Nichols, Portable electrocardiograph, 1,888,139, same, Interference eliminator for electrocardiographs, filed Oct. 14, 1935, D. C., E. D. Mich., (Detroit), Doc. 7260, *H. E. Nichols et al.* v. *Sanborn Co.*

1,682,874, F. K. Vreeland, Radio frequency amplifier; 1,725,433, 1,850,973, same, Band receiving system; 1,730,987, same, Variable band amplifier; 1,749,930, same, Variable circuit element for radio receiving sets, D. C., S. D. N. Y., Doc. E 70/228, *Vreeland Corp.* v. *The Aeolian Co. et al.* Dismissed for lack of prosecution (notice Oct. 8, 1935).

1,329,283, 1,398,665, H. D. Arnold; 1,349,252, same; 1,403,475, same; 1,448,550, same; 1,465,332, same; 1,453,982, B. W. Kendell, D. C. Minn. 4th Div., Doc. E 2837, *H. Dickerman* v. *Western Electric Co. et al.* Dismissed for lack of jurisdiction Oct. 17, 1935.

Re. 18,579, Ballantine & Hull; 1,297,188, I. Langmuir; 1,573,374, P. A. Chamberlain; 1,618,017, F. Lowenstein; 1,707,617, 1,795,214, E. W. Kellogg; 1,894,197, Rice & Kellogg, same, filed Oct. 25, 1935, D. C., S. D. N. Y., Doc. E 81/288, *Radio Corp. of America et al.* v. *B. Shaw (Shaw Radio Co.)*. Doc. E 81/289, *Radio Corp. of America et al.* v. *H. & B. Radio Corp. et al.*

1,755,114, L. A. Hazeltine, Unicontrol signaling system; 1,755,115, same, Variable condenser, D. C., S. D. N. Y., Doc. E 72/385, *Hazeltine Corp.* v. *Lang. (Lang Radio Co.)*. Consent order of discontinuance (notice Oct. 28, 1935).

1,203,190, C. E. Fritts et al., Apparatus for recording and reproducing pulsations or variations in sound; 1,213,614, same, Record of pulsations of sound and analogous phenomena and process and apparatus for producing same, 1,223,496, I. Langmuir, Electrostatic telephone system; 1,313,094, same. System for amplifying variable currents; 1,316,967, D. M. Moore, Gaseous conduction lamp; 1,756,863, C. A. Hoxie, Method of making motion picture films, D. C., S. D. Calif. (Los Angeles), Doc. E Y-6-H, *R.C.A. Photophone, Inc., et al.* v. *Disney Film Recording Co., Ltd., et al.* Dismissed Nov. 1, 1935.

1,297,188, I. Langmuir, 1,639,713, A. F. Sykes, Reproduction of sound; 1,885,001, F. H. Olson, Apparatus for converting sound vibrations into electrical variations; 1,897,732, Olson & Kreuzer, System for the conversion and transfer of energy, filed Nov. 6, 1935, D. C., S. D. N. Y., Doc. E 81/312, *Radio Corp. of America et al.* v. *Amperite Corp. et al.*

1,266,988, Pridham & Jensen, Amplifying receiver; 1,881,324, H. E. Metcalf, Signal reproducer, D. C., N. D. Calif. (San Francisco), Doc. E 3497-K, *The Magnavox Co.* v. *Victory Speakers, Inc.* Dismissed for want of prosecution Nov. 4, 1935.

British Patents

Radio Circuits

Reflex circuit. A superheterodyne receiver with a reflexed panta-grid converter which becomes a combined local oscillator, mixer and i-f amplifier. E. K. Cole, N. 426,802.

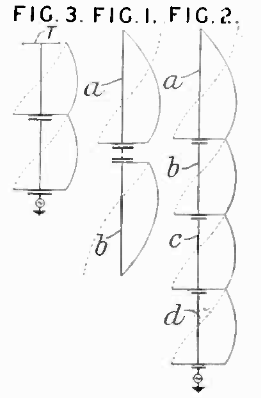
Scanning system. A revolving image is formed by means of a rotating internally reflecting prism. I. L. Maguire, Victoria, Australia. No. 425,971.

Tone control. In a resistance-capacity coupled amplifier the frequency response is varied by the use of an inductive coupling associated with the output circuit and connected between the grid of the following tube and its grid-leak. Ferranti, Ltd. No. 435,878.

Direction finding. The direction of a radio beacon station is determined from an elevated or free point in space by a composite aerial comprising a closed loop and a dipole, the latter being fixedly mounted at right-angles to the former on a common support. The pick-up from both aerials is separately amplified, and the two outputs are fed to a common indicator. The dipole points to the beacon when the indicator shows zero reception, that is, when both the magnetic and electric lines of force lie in the plane of the loop. The separate aerial voltages may be fed to a common amplifier, providing one is phase-displaced by 90 deg. Telefunken. No. 436,186.

Antenna system. An aerial of the type comprising two or more elements capacity-coupled in series, the length of at least one of the elements is less

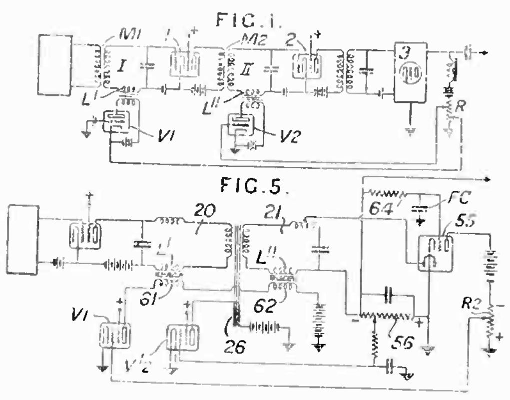
FIG. 3. FIG. 1. FIG. 2.



than half the working wavelength. The average overall current is at least 0.7 of the maximum current, while the current at all points of at least one element exceeds 0.5 and may reach 0.9 of the maximum current. H. L. Kirke, London. No. 436,254.

Band selector system. In a receiver having a band-selector comprising several tuned circuits means are provided to detune these circuits with respect to one another to vary the band width automatic volume control compensates the variation in response. W. A. MacDonald, Hazeltine Corp. No. 436,403.

Variable selectivity. The selectivity of a receiver is varied inversely as the received signal strength by rectifying the received signal and employing the d-c voltage so obtained (1) to vary in opposite directions the tuning or (2) to vary the degree of coupling, of two



or more frequency-selective circuits. The d-c voltage may be applied to the grids of tubes the plate currents of which vary the degree of saturation of the iron cores of coils in the tuned circuits. R. A. Braden, Marconi Co. No. 436,482.

Television

Scanning system. The rapid component of scanning is given by a cathode ray beam while a rotating mirror provides the slower scanning component. No. 431,827.

Light-valves. Optical valves such as those using the Kerr or Faraday effects have the solid polarizing and analyzing devices wholly immersed in a transparent liquid. G. W. Walton, Soho, London. No. 431,958. See also No. 432,017 to Walton.

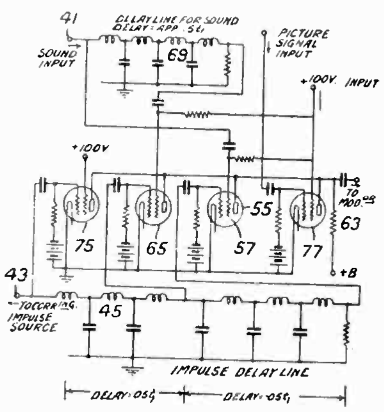
Narrow band system. A record of a scene is transmitted at a speed less than that at which it was produced so that the signals occupy a frequency band similar to that normally used in broadcasting. The scene is scanned by a cathode-ray tube of the Iconoscope type, which controls a Kerr cell to produce a photographic record. The patent states that the synchronous motors tying the transmitter and receiver together are operated at such a speed that the signal frequency does not exceed 9,000 cycles. Automatic Electric Co., Liverpool. No. 432,199.

Interlaced scanning. Where the line frequency is a whole number plus a fraction times the frame frequency, the line and frame deflecting sawtooth oscillators are controlled by oscillations derived from a single oscillator whose frequency is a multiple of both the line and frame frequencies. A. V. Bedford, Marconi Co. No. 434,469. See also No. 434,496 to R. S. Holmes, Marconi Co., on a system in which synchronizing signals and picture signals are transmitted over the same channel, the synchronizing signals being of opposite sense to the picture signals, the average illumination or background brilliancy is controlled by means which separates from the combined signal that portion which lies on the same side of the zero line as do the synchronizing signals.

Interleaved scanning. A television transmitter employing interleaved scanning cooperates with a receiver, adjacent scanning lines at the transmitter being superposed at the receiver. J. L. Baird. No. 434,527.

Scanning system. In a cathode-ray transmitter in which the speed of scanning is varied while the intensity of the ray remains constant, transmission is effected by means of frequency modulation or phase modulation in order that fading may not produce loss of synchronism. D. S. Loewe, Berlin. No. 433,295.

Transmitter system. During intervals between the scanning of successive lines, a carrier is modulated by signals representing sound, which occurs during the periods of scanning the lines. A. V. Bedford, Marconi Co. No. 434,882. See also No. 434,890, to V. K. Zworykin, Marconi, in a combined television and telephone system wherein the sound occurring during a relatively long period is transmitted during a relatively short period. This inven-



tion enables the time taken by the return of a scanning cathode-ray to the beginning of successive scanning lines to be used for sending accompanying sound. Also No. 434,891 to H. Branson, Marconi, on a similar subject.

Scanning system. The subject is explored by periodically interrupted light generated by a cathode-ray tube. The interrupting frequency is above 100,000 per second and is used as a carrier frequency. The photo-electric current is fed to amplifiers with a lower cut-off frequency so high that the interrupting frequency and at least one modulating side band are passed but not lower frequencies. The speed of the light spot on the screen is so related to the periodicity of interruption by the high-frequency oscillator that during each active period of the ray it falls on fresh fluorescent material. A. W. Vance, Marconi Co. No. 434,936.

R-F Power Measurements

[Continued from page 31]

voltmeter is not necessary—it being sufficient simply to measure the direct rectified current. Any type of stable resistance units capable of carrying the load will function satisfactorily; there are no restrictions as to radio-frequency or inductive characteristics, and it is comparatively easy to build up a variable or adjustable load for test or for optimum output.

So long as the load resistor is adequately bypassed for alternating currents, the total power consumed therein is the d-c wattage. The power expended in an 80-type rectifier is given in the curves of Fig. 6. The total of the d-c power in the load plus that in the rectifier equals the r-f power.

The data in Fig. 6 were obtained in 60-cycle measurements by subtracting the d-c power output from the 60-cycle power input. They will be substantially true at radio frequencies. There is some variation in the rectifier loss which depends on the size of the load resistance, and the data given are least accurate at loads less than 2000 or 3000 ohms. However, the net error is of a low order since the rectifier power is added usually to a much larger load power. In a series of more than twenty measurements under a variety of conditions, the r-f power measured as above checked values measured with the peak voltmeter within an average of 3 per cent. The maximum deviation was 7 per cent.

Some care should be exercised in push-pull or parallel hookups of one or more tubes, to determine the actual direct current for each plate, after which the losses for all plates can be read off and summed up. Total loss vs. total rectified current has been plotted for a single plate of the 80 tube connected as a half-wave rectifier, and for two plates connected either push-pull or in parallel half-wave. If four plates (two tubes), are operated, divide the total rectified current by 4 to get the current per plate; read off the curve the loss for one plate, then multiply this figure by 4 to get the total rectifier loss in watts. Figuring the peak voltage at 700 and the rectified current at 500 milliamperes, two 5Z3 tubes in push-pull parallel will, entirely within rating, measure 350 watts r-f power. At the other extreme, an 80 tube will give accurate results on 1 watt r-f.

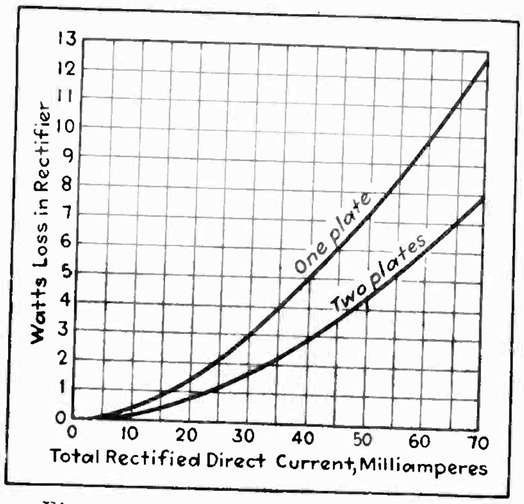


Fig. 6—80-type rectifier loss data

The same considerations concerning d-c plate or bias voltages apply to the dummy load as were outlined for the peak-reading rectifier voltmeter. It probably would be more economical to insulate the dummy load apparatus for the plate voltage than to acquire blocking condensers and chokes suited to carry heavy loads.

In conclusion, to recapitulate briefly: at radio frequencies, power can be measured with an average accuracy of 10 per cent, by one of the following approximations: Using a peak-reading rectifier-type voltmeter calibrated on 60 cycles and corrected for r-f.

Grid driving power (watts) = Peak volts (grid to cathode) times total grid d.c. (amperes).

Using a rectifier-type dummy load —R-F Power (watts) = Rectifier loss (watts) plus d-c power (watts) in load.

[1]H. P. Thomas **Proc. I. R. E.**, August, 1933, p. 1134.

Remote Control via 5 Meters

[Continued from page 17]

teristics for the operation of a high speed keying relay — twenty-five words per minute is about the maximum handling capacity of the present receiver. This low receiver sensitivity was further complicated by the serious reduction in field strength which occurred when a ship intersected the path between the transmitter and receiver.

The present set-up employs a vertical antenna system approximately one-quarter wavelength long. The expected bad effects from the buildings and from the large metal statue have most fortunately failed to materialize.

Keying is done over a metallic circuit, although in emergencies (such as the cables being "out") the keying is handled by the radio link. The metallic circuit, which is about 13 miles long, extends by government-owned cable from Governors Island to the Barge Office at South Ferry; thence over Bell System circuits to Black Tom, N. J., where it again joins a government cable for the under-water jump from Black Tom to Bedloe Island.

As might be expected, the operation of the system is simple to the extreme. The operator at Governors Island connects the dial to the modulating frequency of 600 cycles. Dialing a two-digit number starts one of the transmitters which is then keyed over the metallic circuit. If it should be necessary to key over the radio link, the 1,500 cycle modulation is applied to the five-meter transmitter; these 1,500 cycle impulses actuate a 1,500 cycle relay at the receiving end for the actual keying. Shutting down the active transmitter is accomplished by another two-digit number which is dialed as in starting.

The writer wishes to acknowledge his indebtedness to the Signal Corps personnel at Fort Jay, Governors Island, for their courtesy in making this material so readily available; and especially to Mr. H. G. Phair, Chief of the Communication Division.

Air Navigation

[*Continued from page 34*]

ally be accumulated by experience, but a program involving measurements is completely impractical now. The stations selected must therefore be chosen on theoretical considerations which may well be proved in error in a few cases but which can be depended upon on the whole to give usable information.

Stations most suited to the purpose are 50 kw. transmitters operating on channels completely free from interference, i.e. on which no other stations in North America are assigned to the same frequency. If this restriction were to be adopted as final, the list would contain only seven stations, located in five cities (three of these stations serve Chicago). The "clear" channels listed by the FCC (640-680, 700-720, 740-770, 790-830, 850-870, 970-1000, 1020, 1040-1110, and 1130-1190 kc., inclusive) contain over fifty stations, including all those of 50 kw. power. These stations experience the least trouble with interference caused by simultaneous operation, and in addition there are only one or two cases of shared-time operation among them. Stations having assigned frequencies on these channels were selected, therefore, as the basis of the list. There are undoubtedly many stations operating on other channels which can be used by pilots with complete success, but as no means of distinguishing between such stations and those not suitable was available, the arbitrary restriction to "clear" channel stations was necessarily adopted.

Information on the geographical locations, power, and frequency assignments of these stations was obtained from the Berne list with all subsequent available corrections to January 15, 1936. In addition, information was requested by postcard from the staff of each station regarding the location of the antenna with reference to the center of the nearest large town or other landmark, and also checking the latitude and longitude figures. The information so obtained is included in the table.

On all but seven of the channels some sort of interference exists, except on seven additional channels which are clear at night. (Daytime operation is of greatest importance to the pilot, since the "night" effect makes direction finding at night less useful). To evaluate the interference probabilities on the remaining channels, it was necessary to make assumptions which would indicate the relative probability of interference. The assumptions are (1) that the signal strength [in voltage] of both the desired and interfering station varies inversely as the square of the distance from the station, and (2) that the stations were operating with an average power output commensurate with their listed power rating. On these assumptions it was possible to evaluate the ratio of signal voltages from the desired and interfering stations at any desired geographical point. The point chosen was one hundred miles from the desired station in the direction of the interfering station [or in the case of several interfering stations, in the direction of the station having the most power, and or being nearest, i.e. having the highest interference potentialities]. This point represents approximately the worst condition to be encountered by the pilot, who seldom depends on signals at a greater distance than 100 miles, especially at night. The ratios so calculated were then expressed in db and the ratio in db subtracted from the number 80, in order to provide a positive number whose value increases as the interference increases. The formula actually used can be expressed as:

"Interference factor" =

$$80 - 20 \log_{10} \left[\sqrt{\frac{P_1}{P_2}} \, \frac{(d-100)^2}{(100)^2} \right]$$

where P_1 and P_2 are the power ratings of the desired and interfering stations, respectively, and d is the distance between them in miles. No great claims can be made for this factor on the score of predicting interference ratios, especially at night when signal strengths often decrease inversely as the first power of the distance or even more slowly, but it is a good approximation in daylight conditions, and will serve for comparison purposes.

The six stations now operating under synchronized conditions are marked "S" and no interference ratio is given for them, although it could be computed by the formula. Such stations can produce highly erroneous bearings and should be used with caution.

Door Openers

[*Continued from page 36*]

in and one going out. The automatic doors get all the traffic. The other doors are required by fire ordinance and would be necessary to empty the building quickly in case of fire. This suggests the use of two automatic doors, the rest being of less-than-usual weight and cost. Other typical entrances recently equipped:

- Forum Building, Sacramento, Cal.—4 doors.
- Knickerbocker Theatre, Nashville, Tenn.—2 doors.
- Alvin Theatre, Pittsburgh (not so recent).
- Marine Museum, of the Newport News Shipbuilding Co.—2 doors.

Besides this partial list of installations in the United States, equipment has been sold in Canada, Uruguay, Argentina, Sweden, France, Mexico and Japan.

The waiters have not lost out altogether, for recent installations for their convenience include:

- Hotel New Yorker—2 doors out of the above 6.
- General Electric Restaurant (for executives), New York—2 doors.
- Rainbow Room, Rockefeller Center, New York—2 doors.
- B. & B. Bar, Pensacola, Florida—4 doors.
- Longchamps Restaurant, New York—2 restaurants, 2 doors each.
- Stern Bros. Department Store, New York — 2 doors.
- Jones Beach Restaurant, Long Island—2 doors.

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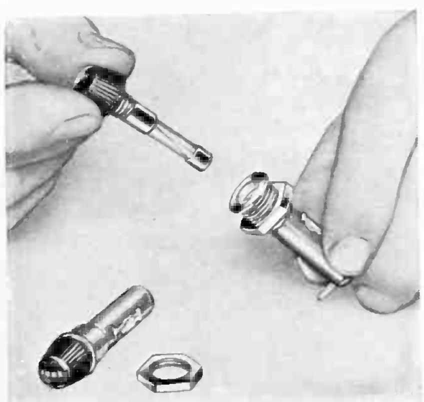

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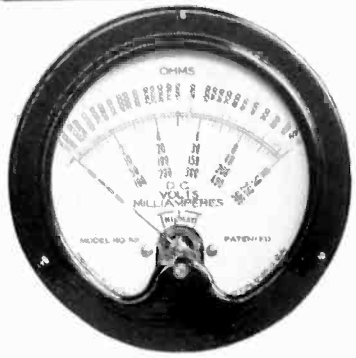

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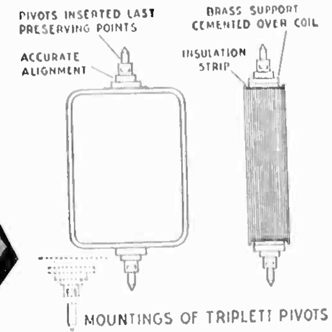

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